7. GEOLOGY AND SOILS

7.1 Introduction

The geologic and geomorphic conditions in the JDSF are described in the DFMP (see discussions in Chapter 2, within the watersheds section on soils; geology; topography; and surface erosion, road-related erosion, and mass wasting). In addition, because JDSF operates as an experimental forest, considerable research has been conducted on the impacts of various management approaches on the geologic condition of the landscape. This is particularly true within the Caspar Creek watershed, where studies have focused on the relative impacts associated with various silvicultural and yarding methods for over 40 years.

A list of pertinent studies of the geologic and geomorphic characteristics of the JDSF includes:

- The most comprehensive discussion of watershed studies within the Caspar Creek drainage is U.S. Forest Service General Technical Report PSW-GTR-168, “Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story”;

- An entire catalog of Caspar Creek studies is accessible on-line at: www.rsl.psw.fs.fed.us/projects/water/caspar. Pertinent recent studies available at this web site include Lewis et al. (2001) and Zeimer (2001);

- The California Geological Survey recently compiled preliminary geologic and geomorphic maps of the Noyo River and of JDSF lands showing existing landslides and “relative landslide potential”: The JDSF map is currently being updated with recent field mapping that started in 2000 and continues into the present. The updated mapping is used for project preparation and will be published in the near future, replacing the 2002 map.

    Watershed Mapping Series, Map Set 1
    Geologic and Geomorphic Features Related to Landsliding, Noyo River Watershed, Mendocino County, California; Landslide Potential Map with Geologic and Geomorphic Features, Noyo River Watershed, Mendocino County, California
    http://www.consrv.ca.gov/cgs/thp/noyo.htm (Manson, Sowma-Bawcom, and Parker 2001)

    Watershed Mapping Series, Map Set 2
    Preliminary Map of Geologic and Geomorphic Features Related to Landsliding, (color), Jackson Demonstration State Forest, Mendocino County, California;
    ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/jdsfcolor.pdf (Short and Spittler 2002a)

Watershed Mapping Series, Map Set 2
Preliminary Landslide Potential Map with Geologic and Geomorphic Features, Jackson Demonstration State Forest, Mendocino County, California; ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/jdsfpot.pdf (Short and Spittler 2002b).

- Landslide mapping within the Caspar Creek watershed is depicted in Spittler and McKittrick (1995);

- The shallow landslide potential within the JDSF has been modeled via a distributive computer model (SHALSTAB) based on digital elevation data, drainage area, and slope (unpublished report for JDSF). These data were used in the development of the CGS preliminary map of relative landslide potential;

- Sediment Storage and Transport in the South Fork Noyo River Watershed, Jackson State Demonstration Forest (Koehler 2001);

- A study was completed by the California Geological Survey (CGS) (Bawcom 2005) to evaluate the frequency of landslides in areas under even-aged management.

- The California Geological Survey (CGS) has completed a number of useful maps and GIS coverages for landslide and geomorphic features and for relative landslide potential in the Noyo River basin:

  Watershed Mapping Series, Map Set 1
  Map of Geologic and Geomorphic Features Related to Landsliding (west & east color), Noyo River Watershed, Mendocino County, California; (Manson and Bawcom 2001)ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/noyo_color_west.pdf
  ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/noyo_color_east.pdf

  Watershed Mapping Series, Map Set 1
  Landslide Potential Map with Geologic and Geomorphic Features, (west & east), Noyo River Watershed, Mendocino County, California; (Manson and Bawcom 2001)
  ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/noyo_pot_west.pdf
  ftp://ftp.consrv.ca.gov/pub/dmg/thp/maps/noyo_pot_east.pdf

- An on-going study is being conducted by CGS to map and characterize inner gorge slopes within JDSF [published in Bawcom (2004)]; and

- Numerous site-specific geologic studies have been conducted for individual THPs within the State Forest.

Appendix 11 to this EIR, Overview of Existing Sediment Studies Relevant to the JDSF EIR, provides an important summary of many studies of sediment sources on the Big and Noyo River watersheds and JDSF. The preceding studies, other published literature and maps, and Appendix 11 are the basis of the following discussion.

7.2 Regional and Project Setting

7.2.1 Geology

JDSF is located along the west side of the Coast Range geomorphic province in Mendocino County. The area is underlain by bedrock of the Mesozoic to Cenozoic age Coastal belt of the Franciscan Complex (Kilbourne 1986, Short and Spittler 2002a). The Franciscan Complex is a regional accretionary assemblage of bedrock materials representing the accumulation of ancient seafloor rocks and deposits along the western edge of the North American plate during subduction of the Pacific plate over the past 120+ million years. In simple terms, as the Pacific plate was subducted (from west to east) beneath the North American plate, some seafloor materials were scraped off and become “welded” (i.e., “accreted”) to the continental margin. These rocks and sediments are extensively sheared, folded, mixed, and metamorphosed during this process, resulting in a heterogeneous assemblage of earth materials. The Franciscan Complex can be subdivided into three broad northwest-trending belts that span much of the Coast Ranges in northern California (Irwin 1960). These belts, which become progressively younger from east to west, are generally referred to as the Eastern, Central, and Coastal belts. These belts, in turn, are subdivided into structural “terranes” that define discrete zones of accreted materials, based on the age, lithology, or metamorphic character of the particular rocks.

The youngest of the three belts, the Coastal belt of the Franciscan Complex, underlies most of JDSF. The Coastal belt itself is subdivided into a series of terranes, the largest and most extensive of which is simply referred to as the “Coastal terrane.” JDSF Coastal belt bedrock is part of the Coastal terrane. The Coastal terrane is composed of graywacke sandstone and argillite (shale), with minor amounts of conglomerate and altered basalt. Rocks within the Coastal terrane are typically pervasively sheared, although deformation is less intense in the western part of JDSF. Fossils within the Coastal terrane rocks between Fort Bragg and Willits are Paleocene to Eocene in age (about 33 to 65 million years old), although older (over 65 million years old) and younger (less than 23 million years old) fossils have been identified elsewhere (see discussion in DFMP). No fossils have been found on JDSF to date.

The geomorphology of the coastal mountains of Mendocino County has been strongly influenced by two important factors: tectonic uplift and fluctuations in sea level. Tectonic uplift in the region is a result of the structural setting along the western margin of the North American plate. Uplift was originally associated with subduction along the plate margin, but has evolved over the last approximately 8 million years as the San Andreas fault system developed. Superimposed on this uplifting, emergent coastline are the effects of fluctuating sea level. Sea level during the Pleistocene epoch (2 million to 10,000 years ago) has fluctuated due to changes in the global water budget resulting from glacial advances and retreats. During glacial periods, sea level drops substantially; during interglacial periods (such as the present), sea level rises. The geomorphology of coastal watersheds is most significantly impacted during low sea level stands, when the ocean shoreline migrates to the west. Coastal streams down-cut to reach the reduced sea level, resulting in deeply incised stream valleys with steep-sided inner gorges. This combination of tectonic uplift and sea level-induced stream incision results in the steep, immature geomorphic expression that characterizes the region. During high sea level stands, the streams aggrade to compensate for the encroaching shoreline, thus filling the floors of coastal valleys and creating estuaries at the mouths of many coastal streams.

As the shoreline advances and recedes during sea level changes, wave-cut platforms are eroded along the migrating coastline. When associated with a high sea-level stand (during an interglacial period), the wave-cut platform occurs the farthest to the east, becomes less susceptible to reworking by later shorelines, and has a higher probability of being preserved. Along emergent coastlines such as California's, these high stand wave-cut platforms are often elevated out of the reach of later shorelines, and preserved as marine terraces. Marine terraces are common along the coast of North America (Lajoie 1986), typically consisting of a wave-cut platform (dipping a few degrees toward the ocean) overlain by a sequence of nearshore marine (beach) and terrestrial (fluvial, colluvial) deposits. A sequence of at least seven marine terraces has been identified along the Mendocino coast; these terraces increase in age from west to east, as the terraces increase in elevation.

Dune deposits overlie the marine terrace deposits in the western part of JDSF. These loose to partially indurated sandy deposits generally occur as northwest-trending ridges up to several thousand feet long, several hundred feet wide, and up to 50 feet thick. The orientation of the dunes reflects the predominant wind pattern (i.e., northwesterly) during the dry season, when sand is mobile.

Hillslopes in the study area are covered with a veneer of late Pleistocene to Holocene age (last 10,000 years to present) colluvium. This veneer represents the accumulation of weathered and/or reworked rock and soil that moves downslope via gravitational processes. It includes the debris deposited by landslides, so in some cases can be very thick. In general, colluvial thickness is greatest within swales (i.e., colluvial "hollows") and at slope toes where it is deposited as a colluvial apron. The texture and consistency of colluvial materials is a manifestation of the parent material from which it is derived. Colluvium derived from the blocky, durable sandstone present within much of the Coastal terrane is often gravelly.

7.2.2 Soils

Regional soils are closely related to parent materials and geomorphology from which they form. Parent materials within the Coastal Terrane are relatively uniform with sandstone predominating, and the Coastal Terranes have unique soils due to development on marine terrace and sand dune deposits. Moving inland, bedrock is primarily sandstone, and soil development varies with topographic position on ridges, steep sideslopes, wavecut marine terraces, and stream bottoms. Soil characteristics also change dramatically on the west side of the San Andreas Fault, which comes onshore south of the Forest near the coastal town of Manchester.

The basic soil units mapped in the JDSF EIR assessment area are depicted in Map Figure U. A more detailed soils map and related soils data can be found on the NRCS web site (http://www.ca.nrcs.usda.gov/mlra02/wmendo/). Throughout the forested areas of JDSF, soils are chiefly characterized by inceptisols with slight subsoil development, ultisols with leached, base depleted subsoils that developed under forest cover (Donley et al. 1979), and alfisols with well developed subsoils that are found in the eastern portions of the JDSF assessment area.

In the eastern one-third of this assessment area, soils are dominated by the Ornbaun, Zeni and Van Damme series, which form from deeply weathered bedrock on less steep slopes and on ridges. These are deep soils (up to about 60 inches) formed from weathered sandstone and mudstone that are well-drained, and contain 35 to 45 percent clay and 0 to 10 percent gravel (Zeimer and Albright 1987).

In the western two-thirds of the JDSF assessment area, the Irmulco and Tramway series are the most common soils found on sideslopes. These soils are loamy, moderately deep to deep (up to about 80 inches), well-drained, and formed from weathered sandstone. In the North Fork Caspar Creek basin, Irmulco and Tramway soils are typically found on the middle portions of hillslopes (Napolitano 1996). Van Damme soils also are common in this area on the upper portions of hillslopes and on ridges (Zeimer and Albright 1987).

Inner gorge areas and the lower margins of hillslopes in the North Fork Caspar Creek basin are often characterized by gravelly Dehaven-Hotel complex loams (Napolitano 1996). Valley bottoms contain gravelly, deep, moderate- to low-permeability soils, and floodplains found along the southern margin of JDSF are mantled with sandy, deep, highly permeable Big River soils.

Soils found on marine terraces include the Cabrillo, Heeser, Ferncreek, Quinliven, Shinglemill, Gibney, and Caspar series; many of the soils in the flat marine terrace areas are poorly drained. Marine terrace soils are generally sandy with high permeability and range from shallow to deep. Some marine terrace soils have developed an iron-rich hardpan, which leads to poor drainage, and have low fertility. This combination of conditions restricts vegetation growth and has resulted in the formation of pygmy forests.

Areas with potential for asbestos-bearing rocks or soils have been identified just to the east of the JDSF boundary (see, e.g., the website of the Mendocino County Air Quality management District, http://www.co.mendocino.ca.us/aqmd/pdf_files/MCAQMD NOA PLS.pdf). Asbestos most commonly occurs in ultramafic rock that has undergone partial or complete alteration to serpentine rock (serpentinite), which often contains chrysotile asbestos. Another form of asbestos, tremolite, can be found associated with ultramafic rock, particularly near faults. However, existing soil surveys and geologic mapping as well as field observations by staff soils scientists and geologists do not indicate the presence of asbestos-bearing soils or parent material within JDSF (Munn pers. com. 2004, Bawcom pers. com. 2004, Clinkenbeard et al. 2002, Churchill and Hill 2000). Exposure and disturbance of rock and soil that contains asbestos can result in the release of fibers to the air and consequent exposure to the public. See the Air Quality section of this DEIR for further discussion of asbestos and air quality issues.

7.2.3 Seismicity

Northern California is a seismically active region. Since 1853, approximately 110 moderate to large earthquakes have been documented in the northern California Coast Ranges (Stover and Coffman 1993; Toppozada and Parke 1982; Dengler 1992). Many of these were probably felt in the JDSF region. There are no large magnitude earthquakes whose epicenters have been documented in the region during historic times, although the 1906 San Francisco earthquake apparently ruptured along the San Andreas fault offshore to the west. Reports of the 1906 earthquake from the Lawson Report (1908) state that in Willits “Brick chimneys were quite generally wrecked. The Buckner Hotel was completely demolished killing the proprietor Mr. Taylor. All brick buildings were damaged to some extent.” On November 22, 1977, a magnitude 4.8 earthquake stuck near Willits, which was probably felt on the Forest (Simon, Pamegan and Stover 1978).

The Forest is located between two active seismicity centers, the San Francisco Bay area to the south and the Mendocino Triple (Plate) Junction to the north. The principal tectonic feature in the area, as throughout much of California, is the San Andreas Fault, which is located about 6 miles offshore of the Forest (Jennings 1994). The north coast segment of the San Andreas Fault is associated with a slip rate of about 24 mm/yr (Working Group 1996), and last ruptured in 1906.

The other significant seismic source in the Mendocino County area is the Maacama fault, which lies about 6 miles east of the Forest. The Maacama fault is believed to represent the continuation of the Calaveras-Hayward-Rodgers Creek fault system into northern California. The Calaveras-Hayward-Rodgers Creek fault system has an associated slip rate of about 9 mm/yr. The Maacama segment has not produced a large historic earthquake. It is creeping aseismically at a rate of about 6.5 mm/yr (10 years of data; Galehouse 2002). It is interpreted to be capable of generating a maximum magnitude earthquake on the order of 6.9 to 7.1 (Working Group 1996). The Bartlett Springs fault, which is about 28 miles to the east, is associated with a slip rate of about 6 mm/yr, and is capable of generating a magnitude 7.1 earthquake. The site is approximately 68 miles south of the Mendocino Triple Junction, which is perhaps the most seismically active region in the state.

Earthquakes produce several types of ground failure including landsliding, liquefaction, ground fracturing, cracking and fissures, compaction, subsidence and uplift. Steeper forest slopes are prone to mass wasting including rock falls, debris flows and deeper-seated landslides large and small. After the 1989 Loma Prieta earthquake near Santa Cruz, the California Department of Forestry and Fire Protection in cooperation with California Geological Survey completed a study of the Earthquake Damage in Soquel Demonstration State Forest in Santa Cruz (Manson and Bawcom 1992). Types of failures observed include rock falls from near vertical cutslopes along roads, stream bank collapses, cracking along ridges trending for several hundred of feet and the reactivation of very large deep seated landslides from intense shaking. In addition, many redwood treetops were snapped off during the earthquake.

7.2.4 Geomorphic Processes: Surface Erosion and Mass Wasting

JDSF is located in a dynamic geomorphic environment. The combination of steep topography, locally sheared and weakened earth materials, high rainfall, and relative frequent seismicity result in a landscape that is inherently susceptible to erosion and landsliding processes (the latter are referred to herein as "mass wasting"). Land management in this environment can result in increased rates of mass wasting, which typically leads to the production of loose sediment, much of which is transported to watercourses. A significant increase in sedimentation, especially its effect on fish-bearing streams, is one of the primary environmental impacts associated with past forestland management in northern California. As such, the potential for delivery of sediment to area watercourses is the most important potential soils and geology-related impact of the proposed project. In the North Coast region, 39 waterbody segments, including the Big and Noyo Rivers, are listed as having impaired beneficial uses due to anthropogenic sediment inputs. This issue is discussed more fully in the Section VII-7.3, Regulatory Framework, and in Section VII-10, Hydrology and Water Quality.

Naturally occurring surface erosion in the California Coast Ranges typically involves sheetwash and gullying of bare soil areas produced by mass wasting (i.e., landsliding) and fire. Management-related surface erosion in forest lands is typically associated with activities that reduce the protective ground cover and canopy (i.e., harvest activities), increase soil compaction through the use of heavy equipment, and/or concentrate water. Road-related surface erosion and road failures are the largest source of management-related sediment (Reid and Dunne 1984; Cafferata and Spittler 1998, Bawcom 2005), particularly at or near locations where roads cross or divert streams (Furniss et al. 1991).

The discussion of surface erosion and mass wasting processes given below provides a basis for the analysis of potential environmental impacts associated with the proposed management plan.

Harvest Area Surface Erosion

Increased surface erosion resulting from timber harvesting is largely a function of canopy disruption, log yarding, and slash burning. The physical (i.e., mechanical) aspects of timber harvest are typically associated with the greatest increases in erosion rates, particularly where ground-based yarding is utilized. Heavy equipment operation and various yarding and skidding techniques can result in disturbance and exposure of surface soils and in concentration or disruption of runoff. The loss of trees and an intact forest canopy lead to a reduction in rainfall interception, where more rainfall reaches the ground and the ground surface is more exposed to erosion. Susceptibility to erosion varies depending on the soil type, slope, and the amount of understory canopy or slash that is retained on the site to disrupt or filter runoff. Harvest- and site preparation-related impacts on surface erosion are often greatest at the heads of Class III watercourses, where increased surface runoff sometimes causes gully formation and uphill migration of the definable watercourse into previously unchanneled portions of headwall swales (Lewis 1998).

Prescribed fire, used to reduce heavy fuel loads, can reduce the potential for catastrophic wildland fires and the attendant risk of significant erosion on severely burned slopes. Prescribed fires, in contrast to nonprescription fires, generally burn cooler and can reduce related surface erosion through partial retention of the duff layer.

Harvest-related surface erosion is a temporary impact that occurs only until vegetation is re-established. Trees exposed to increased wind effects adjacent to canopy holes, particularly near clearcuts, roads, landings, or other clearings, are susceptible to windthrow, which may also expose areas of soil to accelerated erosion. Burning for site preparation, sometimes used in evenaged timber management, can increase soil erosion by reducing ground cover and, if the fire is sufficiently hot, by creating water repellent layers and slowing the revegetation process. These areas are subject to higher short-term erosion rates because little organic material is retained on the soil surface to promote infiltration and protect against erosion. The effects of different silvicultural and yarding practices on surface erosion in the Caspar Creek watershed are presented in Lewis (1998) and Cafferata and Spittler (1998).

Recreation Area Surface Erosion

Recreational use of the Forest environment also can result in increased levels of surface erosion. Erosion control on recreational trails can be difficult to maintain, especially where foot traffic is heavy, or where trails are utilized by horses or mountain bikes. Horse and mountain bike traffic, in particular, can degrade drainage relief structures (water bars, etc.) on trails, and result in rutting, pitting, and gullying, especially during wet weather use. Maintenance of remote recreational trails frequently must be completed by hand, which can limit the scope of potential repairs. Public forest lands open for recreation also are subject to illegal operation of motorcycles and OHVs, which can cause significant environmental damage in areas without adequate erosion protection. Erosion also may occur as a result of development and use of campgrounds, the Forest Learning Center, , and other developments within the scope of the DFMP. Inappropriate grading and construction of campsites and access roads associated with campgrounds can result in diversion of runoff, concentration of flows, and potential erosion. These effects may be especially problematic where campgrounds within JDSF are clustered in valley bottom sites near watercourses. Recreational use of forest roads during winter closures (trespassing) is another problem that has a potential to increase surface erosion along roads.

Road-Related Surface Erosion

Forest roads represent the largest potential erosion source associated with forest management. Roads have the potential to interrupt, concentrate, and re-direct the natural flow of water across native hillslopes, which can result in increased rates of erosion. A road cut into a hillslope intercepts the flow of sheetwash and shallow subsurface flow, and frequently diverts and concentrates these flows to a single discharge point that is usually closer to a watercourse than where the flow originated. The running surface of a road is commonly a low gradient, unimproved dirt surface that is highly susceptible to erosion, especially where subject to frequent traffic (especially during wet weather). Inboard ditches concentrate flow, which can transport sediment from the road surface and cause erosion both in the ditch itself and at the outlet point, where concentrated flows can cut gullies into previously unchanneled slopes. Cut banks and fill slopes can be subject to failure. Stream crossings usually involve culverts and large quantities of fill, which are subject to failure from plugging and subsequent erosion of the crossing materials. Plugging of poorly designed watercourse crossings can result in diversion of stream flow onto the road surface, resulting in significant erosion of the road prism and incision of a new channel at a different outlet point. Forestland road building has evolved over the past 50 to 60 years as the impacts associated with poorly located and constructed roads have become better understood and watercourse protection has become more of a priority. State-of-the-art practices for road building, maintenance, and abandonment are compiled in Weaver and Hagans (1994), and many of the techniques outlined in this handbook were already in use at JDSF since before its publication.

As described in the DFMP, the existing road network in JDSF reflects the evolution of logging and yarding techniques from the late 19th century to the present. Early mechanical phases of old-growth logging (circa 1870s) utilized railroads to transport logs from the woods. Railroad grades were frequently constructed along watercourses, and many of these low-lying grades were later developed into truck roads. Most of the roads in JDSF were constructed from the 1950s through the 1970s. Roads constructed in that era were frequently placed on lower and mid to lower slope positions to accommodate downhill skidding with tractors, and were commonly located across steep slopes. In addition, the early roads utilized inboard ditches to capture and divert runoff. These roads were large sources of sediment because the inboard ditches concentrated and diverted sediment-laden runoff toward watercourses. Road construction techniques on JDSF lands changed considerably through the 1980s and 1990s. This more recent construction typically has occurred along ridgelines with spur roads to accommodate siting of long-reach skyline yarders. A Road Management Plan is proposed in the DFMP to determine which roads have the potential to contribute large amounts of sediment to watercourses, to establish priorities for road improvement projects, and to develop a road-decommissioning schedule that identifies roads to be rehabilitated or removed.

The best available information on the road network within the cumulative watershed effects assessment area (see Figure V.2) has been compiled in a Geographic Information System (GIS) database. Attributes within the GIS data (i.e., road surface material, relative amount of use, time since construction, use status, etc.) have been applied to a road sediment model, to estimate sediment production. Tables VII.7.1 and VII.7.2 summarize this information. The results of these analyses are limited by the quality of the GIS data layers and the models used. While the remotely sensed GIS data have not been thoroughly ground checked, they meet current professional standards for this kind of analysis. Any interpretation and application of the information from these analyses needs to be done within the limits of the data and models.

There are approximately 2,270 miles of roads within the EIR watershed assessment area, with 1,814 miles outside of JDSF and 457 miles or 20% within JDSF. Riparian roads (roads within 200 feet of a stream, as indicated by the GIS) have the highest potential to deliver sediment to stream courses, depending upon how they are configured, surfaced, utilized, and maintained. The legacy of forest management across the assessment area has left an extensive network of roads adjacent to stream channels. Of the total roads miles, about 910 miles (40%) are riparian roads. Outside of JDSF, 690 road miles (38% of total road miles outside JDSF) are in riparian areas. Inside JDSF, there are 220 miles (48% of total road miles inside JDSF) of riparian roads.

The average road density (miles of road per square mile of drainage) across the assessment area is 6.8 mi./mi.^{2}. Outside of JDSF it is 7.0 mi./mi.^{2}. Within JDSF, the average road density is 6.0 mi./mi.^{2}. Given the potential for roads to generate sediment that may be delivered to streams, lower road densities are generally considered desirable, other factors (such as road location, design, and surfacing) being equal. Road planning should be done to keep road densities as low as practicable and should include the survey and planned abandonment of the most problematic road segments.

Outside of JDSF, the highest road densities (all roads) are found on Brandon Gulch (14.0 mi./mi.^{2} for the 0.3 square mile private ownership), Little North Fork of the Middle Noyo (8.9 mi./mi.^{2}), and Lower North Fork Big River (8.9 mi./mi.^{2}) planning watersheds. The highest road densities on the JDSF ownership are found in the Kass Creek (11.0 mi./mi.^{2}), East Branch North Fork Big River (8.7 mi./mi.^{2}), and Hare Creek (8.6 mi./mi.^{2}) planning watersheds. Outside of JDSF, the lowest road densities are found on the Leonaro Lake (3.8 mi./mi.^{2}), Russian Gulch (5.0 mi./mi.^{2}), and Dark Gulch (5.2 mi./mi.^{2}) planning watersheds. The lowest road densities on the JDSF are found on the Brandon Gulch (3.6 mi./mi.^{2}), Chamberlain Creek (4.9 mi./mi.^{2}), and Parlin Creek (5.2 mi./mi.^{2}) planning watersheds.

For riparian roads across the assessment area, the average density outside of JDSF is 2.7 mi./mi.^{2}. Inside JDSF, it is 2.9 mi./mi.^{2}. The highest riparian road densities outside of JDSF are found in the Lower North Fork Big River (4.7 mi./mi.^{2}), Two Log Creek (4.4 mi./mi.^{2}), and the Mouth of the Big River (4.1 mi./mi.^{2}), planning watersheds. Within JDSF, Lower North Fork of the Big River and Kass Creek (both at 6.0 mi./mi.^{2}), and James Creek (5.9 mi./mi.^{2}) planning watersheds have the highest density of riparian roads.

To provide a consistent, assessment-area wide estimate of road surface soil erosion, a GIS-based model (SEDMODL2) was used to assess the contribution of roads to surface erosion. SEDMODL2[1] was developed by Boise Cascade Corporation and the National Council on Air and Stream Improvement (NCASI) to identify road segments with a high potential for delivering sediment to streams and to estimate road erosion and delivery. The model uses information from an elevation grid, along with road and stream data to determine which segments of the road system are likely to drain to streams. The relative amount of sediment produced from these road segments is then calculated based on modified road erosion factors taken from the Surface Erosion Module of the Washington Department of Natural Resources Standard Method for Conducting Watershed Analysis (Washington Forest Practices Board 2001) and the Water Erosion Prediction Project (WEPP) soil erosion model. The model predicts surface sediment production from road segments and identifies road segments that have a high potential for delivering sediment to streams based on proximity or delivery of road drainage to the stream network.

The model inputs are derived from detailed GIS databases for roads, streams, and soils. JDSF maintains GIS databases that describe road and stream characteristics. Mendocino Redwood Company provided similar information for the lands that it owns. For other areas outside of JDSF, the information was based on GIS data that were developed to support sediment TMDLs (total maximum daily load limitations) for both the Noyo and Big Rivers (Mathews 2000). Some updates were made to this database using existing digital air photos.

The suitability of the model outputs are limited by the quality of the largely remotely-sensed model inputs and the integrity of the model itself. The model outputs presented here have not been field verified. The sediment model outputs should be considered to be indicative of sediment generation, rather than definitive, and are better considered relative measures than absolute.

[1] For information on SEDMODL2, see the NCASI website at: http://www.ncasi.org/support/downloads/default.aspx?id=5

Table VII.7.1. Road Characteristics and Estimated Sediment Production for the Watershed Cumulative Effects Assessment Area.

		Outside of JDSF						Within JDSF						Entire Assessment Area
Watershed Unit	**Total Drainage Area (mi^2)**	**Drainage area (mi^2)**	**Road Miles**	**Road Density**	**Miles of Riparian Roads**	**Riparian Road Density**	**Road Sediment Rate (t/mi2/yr)**	**Drainage area (mi^2)**	**Road Miles**	**Road Density**	**Miles of Riparian Roads**	**Riparian Road Density**	**Road Sediment Rate (t/mi2/yr)**	**Road Sediment Rate (t/mi2/yr)**
BIG RIVER HEADWATERS	**32.9**	**32.9**	**233.2**	**7.1**	**81.8**	**2.5**	**138.6**							**138.6**
Rice Creek	12.6	12.6	85.7	6.8	28.5	2.3	123.3							123.3
Martin Creek	9.3	9.3	67.1	7.2	21.3	2.3	126.4							126.4
Russell Brook	11.0	11.0	80.4	7.3	32.0	2.9	166.1							166.2
NORTH FORK BIG RIVER	**43.6**	**19.5**	**146.5**	**7.5**	**76.8**	**3.9**	**119.5**	**24.1**	**142.8**	**5.9**	**109.1**	**4.5**	**88.0**	**103.7**
Upper North Fork Big River	8.5	6.2	48.2	7.8	23.9	3.9	137.9	2.2	15.6	7.0	12.3	5.5	127.1	135.2
James Creek	7.0	2.0	15.3	7.7	8.7	4.4	118.2	5.0	35.9	7.2	29.7	5.9	81.5	91.9
Chamberlain Creek	12.3	0.1	1.8		0.0	0.0		12.2	59.5	4.9	39.5	3.2	81.1	80.4
East Branch North Fork Big	8.1	7.8	50.9	6.5	28.3	3.6	122.5	0.3	2.6	8.7	1.1	3.7	242.5	126.5
Lower North Fork Big River	7.7	3.4	30.3	8.9	16.0	4.7	83.9	4.4	29.2	6.6	26.5	6.0	85.4	84.7
SOUTH FORK BIG RIVER	**54.5**	**54.5**	**311.9**	**5.7**	**109.4**	**2.0**	**134.9**							**134.9**
Dark Gulch	11.2	11.2	57.8	5.2	27.7	2.5	82.4							82.4
Daugherty Creek	16.7	16.7	112.8	6.8	33.6	2.0	147.9							147.9
Mettick Creek	18.3	18.3	109.6	6.0	38.9	2.1	171.1							171.2
Leonaro Lake	8.3	8.3	31.7	3.8	9.2	1.1	99.6							99.6
LOWER BIG RIVER	**50.4**	**39.1**	**324.0**	**8.3**	**152.7**	**3.9**	**125.6**	**11.2**	**64.8**	**5.8**	**28.5**	**2.5**	**73.9**	**108.5**
Mouth of Big River (Estuary)	14.9	12.3	106.5	8.7	50.4	4.1	112.1	2.6	14.3	5.6	6.0	2.3	55.2	102.3
Laguna Creek	5.1	5.1	40.1	7.9	10.6	2.1	85.7							85.7
Berry Gulch	12.5	4.7	33.8	7.2	17.3	3.7	174.3	7.8	45.5	5.8	18.4	2.3	78.1	113.9
Two Log Creek	17.9	17.0	143.6	8.4	74.4	4.4	133.9	0.8	5.0	5.9	4.1	4.9	91.8	132.0
BIG RIVER WATERSHED	**181.4**	**145.9**	**1015.5**	**7.0**	**420.7**	**2.9**	**131.2**	**35.3**	**207.6**	**5.9**	**137.6**	**3.9**	**83.5**	**107.0**
NOYO HEADWATERS	**55.2**	**55.2**	**381.3**	**6.9**	**143.0**	**2.6**	**80.0**							**80.0**
Hayworth Creek	11.1	11.1	75.6	6.8	25.5	2.3	70.6							70.6
McMullen Creek	11.0	11.0	60.3	5.5	19.7	1.8	69.9							69.9
Middle Fork N. Fork Noyo River	7.1	7.1	52.7	7.4	20.6	2.9	57.9							57.9
North Fork Noyo River	9.9	9.9	73.2	7.4	32.8	3.3	60.4							58.8
Olds Creek	10.8	10.8	73.8	6.8	31.2	2.9	114.4							113.7
Redwood Creek	5.3	5.3	45.7	8.7	13.2	2.5	116.7							116.7
MIDDLE NOYO	**22.2**	**22.2**	**192.0**	**8.6**	**46.3**	**2.1**	**185.3**							**185.3**
Duffy Gulch	9.0	9.0	74.2	8.2	17.4	1.9	141.8							141.9
Little North Fork	13.2	13.2	117.8	8.9	28.9	2.2	214.9							214.6

Table VII.7.1. Road Characteristics and Estimated Sediment Production for the Watershed Cumulative Effects Assessment Area.

Watershed Unit	Total Drainage Area (mi^2)	Outside of JDSF						Within JDSF						Entire Assessment Area
		Drainage area (mi^2)	Road Miles	Road Density	Miles of Riparian Roads	Riparian Road Density	Road Sediment Rate (t/mi2/yr)	Drainage area (mi^2)	Road Miles	Road Density	Miles of Riparian Roads	Riparian Road Density	Road Sediment Rate (t/mi2/yr)	Road Sediment Rate (t/mi2/yr)
SOUTH FORK NOYO RIVER	**27.4**	**5.8**	**45.7**	**7.9**	**17.8**	**3.1**	**95.4**	**21.7**	**110.7**	**5.1**	**31.4**	**1.5**	**110.6**	**107.4**
Brandon Gulch	10.1	0.3	4.2	14.0	0.0	0.0	27.0	9.8	35.0	3.6	6.6	0.7	140.7	137.1
Kass Creek	5.5	3.1	26.6	8.6	10.3	3.3	122.6	2.4	26.4	11.0	14.4	6.0	104.5	114.8
Parlin Creek	11.8	2.4	14.9	6.2	7.5	3.1	68.9	9.5	49.3	5.2	10.4	1.1	81.1	78.7
LOWER NOYO RIVER	**8.2**	**8.2**	**60.6**	**7.5**	**17.1**	**2.1**	**47.1**							**46.9**
Mouth of Noyo River	8.2	8.2	60.6	7.5	17.1	2.1	47.1							46.9
NOYO RIVER WATERSHED	**113.0**	**91.4**	**679.6**	**7.4**	**224.2**	**2.5**	**103.5**	**21.6**	**110.7**	**5.1**	**31.4**	**1.5**	**110.6**	**104.6**
COASTAL WATERSHEDS	**39.4**	**20.6**	**118.5**	**5.8**	**45.5**	**2.2**	**41.3**	**18.7**	**138.9**	**7.4**	**51.1**	**2.7**	**105.8**	**71.9**
Caspar Creek	8.4	0.8	6.6	8.0	3.1	3.8	58.9	7.6	52.1	6.9	19.8	2.6	128.4	121.7
Hare Creek	9.7	3.3	19.0	5.8	5.3	1.6	30.0	6.4	54.7	8.6	20.7	3.3	119.2	88.8
Mitchell Creek	10.2	7.5	47.6	6.3	17.5	2.3	39.1	2.7	14.9	5.5	6.3	2.3	60.5	44.8
Russian Gulch	11.1	9.0	45.3	5.0	19.6	2.2	45.5	2.1	17.2	8.4	4.3	2.1	41.0	44.7
ENTIRE ASSESSMENT AREA	**333.5**	**257.9**	**1,813.6**	**7.0**	**690.4**	**2.7**	**114.2**	**75.6**	**457.1**	**6.0**	**220.1**	**2.9**	**96.7**	**110.2**

Table VII.7.2. Number of Road Crossings by Subwatershed and Planning Watershed for Assessment Area.

Watershed Unit	Total Road Crossings All Classes					
	Outside of JDSF			Within JDSF		
	Number of Road Crossings	Number of Stream Miles	Crossings Per Stream Mile	Number of Road Crossings	Number of Stream Miles	Crossings Per Stream Mile
BIG RIVER HEADWATERS	600	192	3.12			
Martin Creek	176	53	3.35			
Rice Creek	224	79	2.83			
Russell Brook	200	60	3.31			
NORTH FORK BIG RIVER	398	116	3.44	348	128	2.71
Upper North Fork Big River	151	40	3.81	40	10	3.98
James Creek	43	12	3.45	101	27	3.72
Chamberlain Creek	0	1	0.00	131	69	1.91
East Branch North Fork Big	138	45	3.07	2	1	1.95
Lower North Fork Big River	66	18	3.62	74	21	3.44
SOUTH FORK BIG RIVER	742	313	2.37			
Dark Gulch	174	72	2.43			
South Daugherty Creek	219	98	2.23			
Mettick Creek	260	90	2.89			
Leonaro Lake	89	54	1.66			
LOWER BIG RIVER	727	235	3.09	160	67	2.40
Laguna Creek	87	33	2.66			
Berry Gulch	88	28	3.16	98	49	2.01
Mouth of Big River	228	77	2.95	33	13	2.47
Two Log Creek	324	97	3.33	29	4	6.46
BIG RIVER	2,467	856	2.88	508	195	2.61
NOYO HEADWATERS	1071	344	3.11			
Hayworth Creek	204	63	3.24			
McMullen Creek	172	65	2.65			
Middle Fork N. Fork Noyo River	153	38	4.07			

Table VII.7.2. Number of Road Crossings by Subwatershed and Planning Watershed for Assessment Area.

Watershed Unit	Total Road Crossings All Classes					
	Outside of JDSF			Within JDSF		
	Number of Road Crossings	Number of Stream Miles	Crossings Per Stream Mile	Number of Road Crossings	Number of Stream Miles	Crossings Per Stream Mile
North Fork Noyo River	229	67	3.42			
Olds Creek	209	70	3.00			
Redwood Creek	104	42	2.46			
MIDDLE NOYO	**437**	**156**	**2.81**			
Duffy Gulch	191	68	2.82			
Little North Fork	246	88	2.80			
SOUTH FORK NOYO RIVER	115	42	2.72	165	154	1.07
Brandon Gulch	1	1	0.99	47	66	0.71
Kass Creek	94	24	3.97	58	16	3.73
Parlin Creek	20	18	1.14	60	73	0.82
LOWER NOYO RIVER	103	42	2.44			
Mouth of Noyo River	103	42	2.44			
NOYO RIVER	1,726	584	2.95	166	155	1.07
COASTAL	**263**	**90**	**2.94**	**253**	**108**	**2.35**
Caspar Creek	6	4	1.46	109	46	2.35
Hare Creek	31	14	2.20	108	43	2.49
Mitchell Creek	124	32	3.85	18	11	1.67
Russian Gulch	102	39	2.61	18	7	2.47
ENTIRE ASSESSMENT AREA	4,456	1,530	2.91	926	457	2.03

The model calculates sediment delivery for each road segment based on the following formula:

> Total Sediment Delivery from each road segment (tons/yr) = (Tread * Cutslope) * Road Age Factor
>
> Tread = Geologic Erosion Factor * Tread Surfacing Factor * Traffic Factor * Segment Length * Road Width * Road Slope Factor * Rainfall Factor * Delivery Factor
>
> Cutslope = Geologic Erosion Factor * Cutslope Factor * Segment Length * Cutslope Height * Rainfall Factor * Delivery Factor

The SEDMODL2 results are shown in Table VII.7.1 (above) and Figure VII.7.1. The predicted sediment yield for each road segment was summarized by planning watersheds, subwatershed, and basin. The model results show that for the entire assessment area and all ownerships, the estimated average road sediment rate is 110.2 tons per square mile per year (t/mi.^{2}/year). Outside of JDSF, the rate is 114.2 t/mi.^{2}/year; inside JDSF the rate is 96.7 t/mi.^{2}/year.

Looking at watershed units across all ownerships, the highest average road sediment rates are found on the Big River watershed (107.0 t/mi.^{2}/year), the Middle Noyo subbasin (185.3 t/mi.^{2}/year), and the Little North Fork of the Noyo planning watershed (214.6 t/mi.^{2}/year). The lowest average road sediment rates are found on the Noyo River watershed (104.6 t/mi.^{2}/year), the Coastal Watersheds subbasin (71.9 t/mi.^{2}/year), or the Russian Gulch planning watershed (44.7 t/mi.^{2}/year). Predicted sediment yield among planning watersheds varied widely from 44.7 tons/mi^2/year on Russian Gulch to 214.6 tons/mi^2/year on the Little North Fork planning watershed.

Outside of JDSF, the highest predicted road sediment rates were found for the Little North Fork of the Noyo (214.9 tons/mi^2/year), Berry Gulch (174.3 tons/mi^2/year), and Mettick Creek (171.1 tons/mi^2/year) planning watersheds. Inside of JDSF, the highest predicted rates are found on the East Branch North Fork Big River (242.5 tons/mi^2/year), Brandon Gulch (140.7 tons/mi^2/year), and Upper North Fork Big River (127.1 tons/mi^2/year) planning watersheds. The lowest predicted road sediment rates outside of JDSF were found for the Brandon Gulch (27.0 tons/mi^2/year), Hare Creek (30.0 tons/mi^2/year), and Mitchell Creek (39.1 tons/mi^2/year) planning watersheds. Within JDSF, the lowest predicted sediment rates are estimated for the Russian Gulch (41.0 tons/mi^2/year), Mouth of Big River (55.2 tons/mi^2/year), and Mitchell Creek (60.5 tons/mi^2/year) planning watersheds.

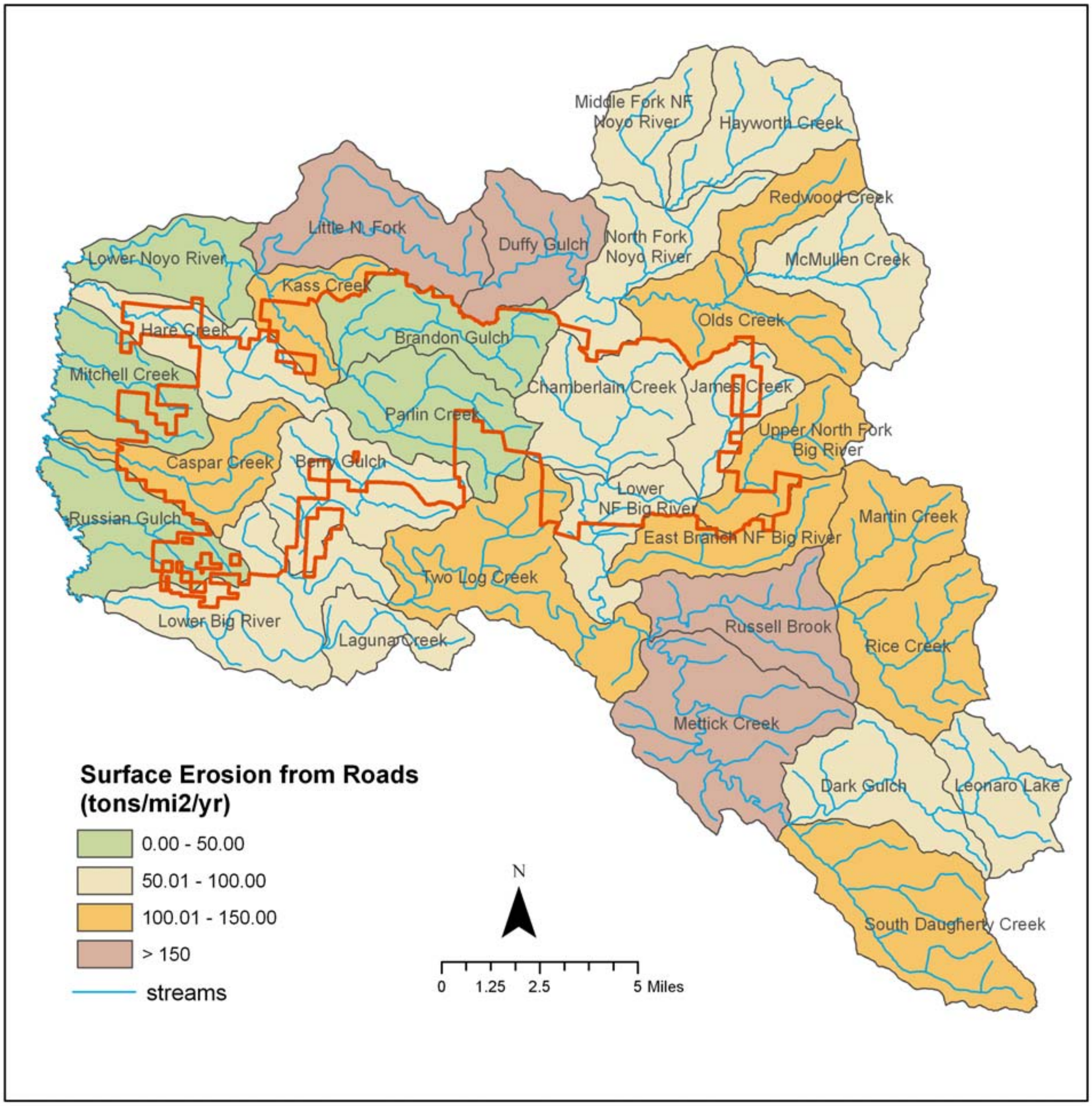

Figure VII.7.1. Estimated surface erosion from roads for planning watersheds across the EIR assessment area.

The differences in estimated sediment production rates between the various assessment units is the result of differences in factors such as slope, road surface, road proximity to watercourses, numbers and types of stream crossings, road age, and rainfall.

The model provides an estimate of sediment production from roads that can support the prioritization of the proposed road inventory as described in the Road Management Plan. It should be repeated that the model results are not supported by field validation and that these estimates are moderately lower than those found in the TMDLs for both the Noyo and Big Rivers and in the rapid sediment budget prepared by Stillwater Sciences for the draft JDSF HCP/SYP, as described in Appendix 11. All of these studies have limitations in terms of the completeness and accuracy of the input data and the precision of the models used, but they represent the best available information. There also have been numerous restoration projects designed to fix road-related problems completed in many of the planning watersheds across the assessment area to reduce future sediment production. Some of these restoration activities are documented in section VIII.2.1 and depicted in Map Figure Y.

Culverts at road and stream crossing have the potential to fail and deliver large quantities of sediment directly to the stream channel. This potential will be evaluated through a rigorous on-the-ground survey and an assessment as part of the Road Management Plan proposed in the DFMP. As a first approximation, GIS-based road and stream data are used here to identify planning watersheds with the highest density of crossings per stream mile (Table VII.7.2). Across the assessment area the average density of crossings per stream mile is 2.71. For JDSF lands on the Big River the density of crossings per stream mile is near the assessment-area-wide average (2.61), but for JDSF lands on the Noyo it is far below the average (1.07). For areas outside JDSF the density of crossings per stream mile is above the assessment area wide average for lands on both the Big (2.88) and Noyo (2.95) rivers. Outside JDSF, the Middle Fork of the North Fork Noyo planning watershed had the highest density of road and stream crossings at 4.07/mile. Within the JDSF ownership, the Upper North Fork of the Big River and James Creek planning watersheds and had the highest density of road and stream crossings, at 3.98 and 3.72/mile, respectively. The lowest numbers of stream crossings per mile (for planning watersheds with more than just a few road miles) are found on the Parlin Creek planning watershed of the Noyo River. Here, there were just 1.14 stream crossings per mile outside of JDSF and 0.82 crossings per stream mile inside JDSF.

The information contained in Tables VII.7.1 and VII.7.2 can be useful to help identify planning watersheds where road types (e.g., riparian and nonriparian), road densities, crossing densities, and road sediment model results suggest that on-the ground examinations are warranted to determine the need to modify roads, upgrade crossings, or abandon and “put to bed” roads that have significant sediment generation potential.

Field surveys in JDSF have indicated that the majority of road-related surface erosion is derived from the road surface, as opposed to erosion of fillslopes or cutslopes. Insloped roads and ditches draining to streams provide a mechanism for transporting this sediment. As such, riparian roads with ditch drain outlets near streams and roads that cross watercourses are the most likely to deliver road-related sediment to watercourses. This situation is true even at Class III watercourse crossings, which are not typically protected by Watercourse and Lake Protections Zones, but can transport sediment to Class I and II watercourses. The highest road-related surface erosion hazard present within JDSF located toward the eastern part of JDSF, where topography is steepest and the highest concentration of Class I watercourse crossings are present

While harvest-related surface erosion is typically a temporary impact, surface erosion from forest roads can be long-term and chronic. A sediment budget constructed for JDSF estimated that 74% of sediment sources were road-related (see section 7.2.5). However, only a portion of this is directly attributed to surface erosion. Road-related sediment sources also included fill failures and landslides associated with roads.

The discussion below under section 7.4 presents the significant steps that the DFMP proposes to reduce surface erosion from various sources, including roads, harvest operations, and recreation facilities.

Mass Wasting

Mass wasting refers to the downslope transport of soil and rock material under the force of gravity. It includes slow displacements such as soil creep, as well as rapid displacements associated with the various forms of landsliding (e.g., earthflow, debris sliding, rotational/translational slides). Mass wasting is a normal process in the Coast Ranges of California due to the steep, immature topography, the weak nature of the sheared, deformed bedrock materials, high regional precipitation levels, and seismic shaking. Timber harvest also is a factor, since it removes trees' evapotranspiration capacity from the hydrologic budget for a harvest slope and removes its canopy interception buffer, both of which result in increased amounts of rainfall that flow across the ground surface (sheetwash) or enter the subsurface. This process may result in short-term elevation of pore pressures during peak storm events (Keppeler and Brown 1998). The relative impact associated with loss of evapotranspiration diminishes into the rainy season, because trees become dormant and the soil, even in forested areas, becomes saturated. Transpiration reductions are relatively short-lived as new trees and other vegetation grow and older, retained trees experience a growth spurt because of the reduction of competition for, nutrients, and sunlight. In addition to hydrologic effects, the cohesive strength of roots in the soil and soil-parent material interface also declines after harvest until this process is reversed by roots produced by new or recovering vegetation. This effect is moderated in redwood forests, because redwoods can resprout, with the new stems utilizing portions of existing root systems.

According to previous geologic assessments (e.g., Spittler and McKittrick 1995 and Bawcom 2005), mass wasting within JDSF is dominated by:

1. shallow debris flows and slides associated with roads and landings;
2. stream-side inner gorge landslides;
3. slow-moving, deep-seated bedrock landslides; and
4. debris flows from areas with steep, youthful geomorphology.

Landslides in the region range in size from small streamside bank failures and hillslope soil slips, to large deep-seated slump-type failures involving thousands of cubic yards of material. Shallow failures on streamside slopes typically occur during high flows due to stream undercutting and loss of toe support in addition to higher pore water pressures created by subsurface transport of infiltrated storm water. Shallow failures on hillslopes tend to occur within the colluvial veneer mantling steeper slopes, and are typically initiated by high pore pressures resulting from concentrated precipitation during winter storms. Elevated pore pressure effects can be enhanced in topographic settings where convergent slopes concentrate subsurface water. Shallow debris slides, therefore, occur frequently in swales and along drainage headwalls. The potential for shallow failures is often increased by the placement of side-cast road fill on steep slopes, which adds additional driving force. Shallow soils also can be sensitive to the loss of the cohesive effects of tree roots, so some shallow slope failures may occur following timber harvest if the root strength loss is substantial enough. This effect is not as important in redwood forests because redwood trees retain a living root mass following harvest and frequently re-sprout from the stump.

Deep-seated failures typically occur as earthflows, slow-moving masses of cohesive fine-grained sheared rock (typically in mélange areas within Franciscan Complex rock types), or as rotational/translational slumps (i.e., rock slides), slow- to rapid-moving failures of coherent rock masses along relatively deep planes of weakness (i.e., shears, joints, weathered zones). Earthflows are generally slow moving and sensitive to moisture changes, and move more under wetter conditions. Slump-type failures are often triggered by dynamic forces (such as seismic shaking) and rapid fluctuations in the water table that result in buoyancy-related reductions in material strengths, or removal of toe support along streams or cuts.

Landslide mapping within JDSF has been compiled by the California Geological Survey (CGS) (Short and Spittler 2002a, Manson and Bawcom 2001). This map compilation supplements previous maps by CGS (see Kilbourne map set from 1982 through 1984); it includes recent field mapping and additional aerial photograph interpretation, as well as additional map sources. Field based geologic mapping is in progress on the State Forest and will replace the 2002 map when completed. Tables VII.7.3 and VII.7.4 provide a summary of the extent of mass wasting features (debris flow, rock slide, earth flow, debris slide, etc.) across most of the assessment area. Included are all of the Noyo River watershed, all of the four coastal drainages, and portions of the Big River where there is significant JDSF ownership.

The landslide types in Tables VII.7.3 and VII.7.4 are broken into roughly two types: shallow and deep-seated. The shallow landslide types include debris flows, debris slides and these types located along a stream channel are called inner gorge. The deeper slide types are rock-slides and Earth flows. Disturbed ground and debris slide slopes are a geomorphic or specific land-form that is observed. A Debris slide slope is generally over 60 percent and is covered with gravelly colluvium that creeps seasonally and disrupted ground is an area that exhibits slope movement including soil creep, soil slumps and other forms but has no definable boundaries.

The landslides of most concern relative to forest management are the shallow type landslides that are formed along natural undisturbed slopes but also can form within a road or landing prism. The current level of geologic mapping that generated these tables is based on remote mapping techniques and these numbers are used as a general tool for the earth scientist and forest manager. Each category is considered and detailed geologic mapping completed in the field prior to any forest management activities. Completed inner gorge field based mapping indicates much less inner gorge than previously mapped remotely. Field based data is continually collected that will systematically replace and refine the remotely based geologic mapping.

In general, this mapping indicates patterns in landslide distribution based on geomorphic conditions and topographic steepness. Slopes in the western part of JDSF are less steep with more mature topography than areas to the east. Historically speaking, recent large deep-seated failures are not present. To the east, where slopes are taller and steeper and road construction is older, shallow debris slides are more abundant. Earthflows are relatively rare within JDSF, and deep-seated failures within JDSF are mostly translational/rotational block slides associated with the competent sandstone of the Coastal terrane.

Landslide distribution in the South Fork Noyo River watershed also was evaluated by Manson and Bawcom (2001). The mapping consisted of a compilation of field mapping, published and published geologic maps, and aerial photographic interpretation of 10 sets of photos. The study indicated that most of the shallow landslides are related to older roads, railroad grades or landings. The more recent geologic mapping in the South Fork Noyo (Bawcom 2005) indicates that road related landsliding has significantly decreased between 1941 and 1999. These changes reflect the improvement in road construction techniques and the shift to ridgeline road locations used by skyline logging methods.

Shallow landslide distribution in the Caspar Creek and James Creek watersheds was evaluated by Coyle and Stillwater (unpublished, undated report to CDF). That analysis involved interpretation of 1978 and 1996 aerial photography and found that, in the Caspar Creek watershed, 53% of shallow landslides were road related, 20% were in inner gorges, and 27% were on other portions of hillslopes. In the James Creek watershed, 60% of shallow landslides were road related, 13% were located in inner gorges, and 27% were on other portions of hillslopes. The aerial photograph analysis also indicated that the number of road-related landslides in the Caspar Creek and James Creek watersheds appear to have decreased by an order of magnitude between 1978 and 1996. This change appears to reflect the improvement in road location and construction techniques and the natural recovery from past damages. This trend was confirmed in landslide mapping within the North and South Forks of Caspar Creek and throughout the Forest (Spittler and McKittrick 1995, Cafferata and Spittler 1998, Bawcom 2004) indicating that roads constructed prior to implementation of the modern Forest Practice Rules continue to be the dominant source of sediment in many areas.

Table VII.7.5 and VI.7.6 present the overall results of CGS modeling of relative landslide potential for the Noyo River watershed and the portions of the Big River watershed covered by JDSF.[2] The modeling is based on the compiled geologic maps and

[2] CGS is working on, but has not yet completed relative landslide potential mapping on the entire Big River watershed.

mathematical model compiled from existing topographic maps that are limited by mapping and data gathering techniques. It is a good tool to utilize before beginning a detailed site specific study. The modeling took into account existing features indicative of instability (e.g., active and dormant landslides, debris slide slopes, inner gorges, disrupted ground), slope, and the SHALSTAB model. It is important to note that landslide potential maps are used as a tool for foresters and others and do not replace the direct geologic field mapping and observations that are regularly used on the State Forest.

7.2.5 Sediment Budget

Sediment budgets are used to allocate estimated sediment production between erosion processes (e.g., surface erosion and mass wasting), sources (including hillslopes, roads, and channels), and changes in storage. Sediment production estimates for the JDSF watershed assessment area are listed and discussed in EIR Appendix 11. This discussion includes the “rapid” sediment budget presented in the DFMP for the planning watersheds within JDSF, which was prepared for CDF by Stillwater Sciences’ as part of a draft JDSF HCP/SYP.

The CDF/Stillwater sediment budget estimate covers the period from 1958 to 1997, so it spans a considerable range in forest management styles. Average sediment yield over this period of time is estimated to have been 856 tons mi^{-2} yr^{-1}, which is approximately 2.5 times greater than estimated background rates from undisturbed watersheds. Proportionate sediment contributions were estimated as follows:

- 74% from road-related surface erosion and road-related landsliding;
- 19% from hillslope landsliding (non road-related), surface erosion, and soil creep;
- 7% from release of sediment stored within channels (primarily due to the removal of large woody debris, which was thought to be a favorable management approach in the 1970s).

Two lines of evidence suggest that sediment inputs have been significantly reduced since inception of the modern Forest Practice Rules, beginning in 1974. First, logging prior to 1974 in the South Fork of Caspar Creek produced 2.4 to 3.7 times more suspended sediment compared to that produced in the North Fork of Caspar Creek under the Forest Practice Rules (Lewis 1998). Secondly, the amount of sediment derived from shallow, road-related landslides was about twice as great between 1958 and 1978 relative to the period between 1979 and 1996, based on interpretation of historic aerial photographs. The amount of road-related sediment input is expected to further decrease under the proposed Road Management Plan within the DFMP.

Additional discussion regarding sediment production is contained in Appendix 11, and more information about stream sedimentation is provided in the discussion of stream channel geomorphology in Section VI-6.1, Aquatic Resources.

Table VII.7.3. Extent of Landslides and Other Forms of Mass Wasting for Noyo and Coastal Planning Watersheds.

NOYO RIVER	Drainage Area (ac)	Outside of JDSF (acres)								Within JDSF (acres)							
		Total Area	Debris Flow	Rock Slide	Debris Slide	Earth Flow	Disturbed Ground	Debris Slide Slope	Inner Gorge	Total Area	Debris Flow	Rock Slide	Debris Slide	Earth Flow	Disturbed Ground	Debris Slide Slope	Inner Gorge
NOYO HEADWATERS	**35,605**	**35,389**	**18**	**11,352**	**121**	**963**	**595**	**9,051**	**312**	**216**		**118**				**4**	
Hayworth Creek	7,112	7,112	3.2	3,035	15.3	54.2	934	1,634	55								
McMullen Creek	7,071	7,071	2.4	1,259	32.6	783.6	250	2,209	6								
Middle Fork N. Fork Noyo River	4,569	4,569	4.3	1,389	13.8	8.9	7	1,040	89								
North Fork Noyo River	6,521	6,346	3.7	1,708	21.6	0.5		1,830	111	175		87				4	
Olds Creek	6,969	6,928	2.6	3,511	18.6	18.1	244	1,079	51	41		31					
Redwood Creek	3,363	3,363	2.2	452	19.3	97.8		1,259									
MIDDLE NOYO	**14,172**	**14,159**	**6**	**2,669**	**78**	**3**	**6**	**4,103**	**399**	**12**							
Duffy Gulch	5,734	5,734	1.2	1,373	16.3	0.9	1	1,646	181								
Little North Fork	8437	8,425	4.4	12,967	61.9	2.6	4	2,458	218	12							
SOUTH FORK NOYO RIVER	**17,560**	**3,726**	**3**	**529**	**2**	**1**		**758**	**76**	**13,834**	**4**	**2,352**	**51**	**28**	**16**	**4,325**	**278**
Brandon Gulch	6,449	205	0.3	5.9	0.1			58	4	6,244	3.2	975	29.4	27.5	5	2,603	128
Kass Creek	3,533	2,001	1.1	410	0.8	0.6		496	49	1,532		489	1.5		12	245	34
Parlin Creek	7,578	1,520	1.2	114	1.1	0.7		204	24	6,058	1.3	888	20.2	0.9		1,477	116
LOWER NOYO RIVER	**5,223**	**5,202**		**123**	**5**	**1**		**359**		**22**							
Mouth of Noyo River	5,223	5,202		123	4.7	0.8		359	98	22							
NOYO RIVER WATERSHED	**72,559**	**58,476**	**26**	**14,674**	**206**	**969**	**600**	**14,272**	**788**	**14,084**	**4**	**2,470**	**51**	**28**	**16**	**4,329**	**278**
COASTAL WATERSHEDS	**25,193**	**13,224**		**0**	**1**			**29**	**307**	**11,970**	**0**	**224**	**15**	**2**	**7**	**410**	**564**
Caspar Creek	5,360	522		0.4				2	8	4,838	0.2	224	15.3	1.6	7	304	260
Hare Creek	6,184	2,106						15	88	4,078						86	227
Mitchell Creek	6,555	4,812						9	69	1,743						20	77
Russian Gulch	7,095	5,784			0.5			4	141	1,311							68

Source: Manson, Sowma-Bawcom, and Parker 2001

Table VII.7.4. Extent of Landslides and Other Forms of Mass Wasting for Portions of the Big River Panning Watersheds with JDSF Ownership.

BIG RIVER	Drainage Area	Outside of JDSF (acres)								Within JDSF (acres)							
		Total Area	Debris Flow	Rock Slide	Debris Slide	Earth Flow	Disturbed Ground	Debris Slide Slope	Inner Gorge	Total Area	Debris Flow	Rock Slide	Debris Slide	Earth Flow	Disturbed Ground	Debris Slide Slope	Inner Gorge
NORTH FORK BIG RIVER	**27,860**	**12,474**	**1**	**242**	**19**	**68**	**24**	**1402**		**15,387**	**17**	**1,708**	**127**	**539**	**38**	**3260**	**872**
Chamberlain Creek	7,868	77						2.3		7,792	14.0	978	93.5	227.8		1,49	439
East Branch North Fork Big River	5,160	4,991	1.1	93	7.2	20.0		596.2	30	169						77	
James Creek	4,459	1,251		59	7.3	26.6		230.4	2	3,208	0.6	245	22.7	234.1	23	1027	161
Lower North Fork Big River	4,953	2,164				6.8	23	23.8	36	2,790	2.0	391	9.1	29.9	16	316	186
Upper North Fork Big River	5,420	3,991		91	4.7	14.5	1	549.6		1,428	0.8	95	1.5	47.3		344	86
LOWER BIG RIVER	**28,981**	**21,771**		**122**	**29**	**59**		**278**		**7,210**	**1**	**15**	**11**	**66**		**579**	**292**
Berry Gulch	7,999	2,979		37	12.8	45.1		136.9	222	5,020							259
Mouth of Big River	9,549	7,903		21	16.1	4.9		72.8	65	1,646	0.5	5	11.1	54.5		533	21
Two Log Creek	11,433	10,889		64		8.7		67.9	14	544		11		11.2		45	11
BIG RIVER TOTAL	**56,841**	**34,245**	**1**	**364**	**48**	**127**	**24**	**1680**	**68**	**22,597**	**18**	**1723**	**138**	**605**	**38**	**3,838**	**1,164**
ENTIRE ASSESSMENT AREA	**154,593**	**105,945**	**27**	**15,038**	**255**	**1,096**	**624**	**15,981**	**1,163**	**48,651**	**22**	**4,417**	**204**	**635**	**61**	**8,577**	**2,006**

Source: Short and Spittler 2002a

Table VII.7.5. Relative Landslide Potential for Portions of the Big River Watershed within JDSF.

SUBBASIN	Acres by Relative Landslide Potential Class*						Percent of Unit Area*					
Planning Watershed	**1**	**2**	**3**	**4**	**5**	**No Data**	**1**	**2**	**3**	**4**	**5**	**No Data**
BIG RIVER HEADWATERS												
Martin Creek												
Rice Creek												
Russell Brook												
NORTH FORK BIG RIVER	537	4,711	7,280	4,726	2,591	8,015	2%	17%	26%	17%	9%	29%
Upper North Fork Big River	20	503	875	739	436	2,846	0%	9%	16%	14%	8%	53%
James Creek	43	901	1,338	1,258	508	411	1%	20%	30%	28%	11%	9%
Chamberlain Creek	137	1,576	3,371	1,763	1,022	0	2%	20%	43%	22%	13%	0%
East Branch North Fork Big	53	510	579	531	319	3,168	1%	10%	11%	10%	6%	61%
Lower North Fork Big River	284	1,221	1,117	435	306	1,590	6%	25%	23%	9%	6%	32%
SOUTH FORK BIG RIVER												
Dark Gulch												
South Daugherty Creek												
Mettick Creek												
Leonaro Lake												
LOWER BIG RIVER	1,628	4,409	3,009	1,805	1,038	17,091	6%	15%	10%	6%	4%	59%
Laguna Creek												
Berry Gulch	560	2774	2,028	1020	741	877	7%	35%	25%	13%	9%	11%
Mouth of Big River	1,021	1,143	622	660	256	5,846	11%	12%	7%	7%	3%	61%
Two Log Creek	46	492	359	125	41	10,369	0%	4%	3%	1%	0%	91%

*1= Very Low, 2=Low, 3=Moderate, 4=High, 5=Very High. Source: California Geological Survey.
Note: Mapping has been completed only for the JDSF portion of the Big River watershed.

Table VII.7.6. Relative Landslide Potential for the Noyo River Watershed and Coastal Drainages.												
SUBBASIN	**Acres by Relative Landslide Potential Class***						**Percent of Unit Area***					
Planning Watershed	**1**	**2**	**3**	**4**	**5**	**No Data**	**1**	**2**	**3**	**4**	**5**	**No Data**
NOYO RIVER	5,874	17,148	23,616	20,903	4,825	0	8%	24%	33%	29%	7%	0%
NOYO HEADWATERS	1,466	5,664	14,358	11,560	2,459	0	4%	16%	40%	33%	7%	0%
Hayworth Creek	207	939	3,126	2,243	576	0	3%	13%	44%	32%	8%	0%
McMullen Creek	339	782	2,313	3,100	518	0	5%	11%	33%	44%	7%	0%
Middle Fork N. Fork Noyo River	105	1,079	1,947	1,179	238	0	2%	24%	43%	26%	5%	0%
North Fork Noyo River	280	1,283	2,682	1,911	353	0	4%	20%	41%	29%	5%	0%
Olds Creek	397	1,097	3,265	1,896	292	0	6%	16%	47%	27%	4%	0%
Redwood Creek	138	484	1,025	1,230	483	0	4%	14%	31%	37%	14%	0%
MIDDLE NOYO	384	4,421	4,186	4,136	1,009	0	3%	31%	30%	29%	7%	0%
Duffy Gulch	78	1,390	2,207	1,739	307	0	1%	24%	39%	30%	5%	0%
Little North Fork	306	3,031	1,979	2,396	702	0	4%	36%	24%	28%	8%	0%
SOUTH FORK NOYO RIVER	943	5,799	4,710	4,907	1,161	0	5%	33%	27%	28%	7%	0%
Brandon Gulch	229	1,481	1,637	2,442	652	0	4%	23%	25%	38%	10%	0%
Kass Creek	168	1,211	1,123	807	218	0	5%	34%	32%	23%	6%	0%
Parlin Creek	546	3,107	1,949	1,658	290	0	7%	41%	26%	22%	4%	0%
LOWER NOYO RIVER	3,082	1,264	362	301	196	0	59%	24%	7%	6%	4%	0%
Mouth of Noyo River	3,082	1,264	362	301	196	0	59%	24%	7%	6%	4%	0%
COASTAL DRAINAGES												
Caspar Creek	1,075	1,670	1,294	411	546	363	20%	31%	24%	8%	10%	7%
Hare Creek	1,878	2,604	740	156	397	410	30%	42%	12%	3%	6%	7%
Mitchell Creek	2,525	727	130	40	199	2,934	39%	11%	2%	1%	3%	45%
Russian Gulch	3,201	454	192	87	274	2,888	45%	6%	3%	1%	4%	41%
***1= Very Low, 2=Low, 3=Moderate, 4=High, 5=Very High. Source: California Geological Survey.**												

7.3 Regulatory Framework

Because the principal geology-related impact associated with forest management in JDSF is an increase in the rate and amount of sediment delivery to area watercourses, the proposed Forest Management Plan and activities conducted under it are subject to Federal, State, and local regulations and policies regarding water quality. These are discussed below.

Federal Clean Water Act. The Noyo River and Big River have been listed as sediment impaired watercourses by the U.S. Environmental Protection Agency, under Section 303(d) of the Clean Water Act. Based on this listing, technical Total Maximum Daily Load (TMDL) reports were prepared, which estimate the existing sediment load and the sources, and define required reductions in sediment input. Significant reductions are required for sediment derived from roads.[3] The Big River is on the 303(d) list for temperature. Caspar Creek was recommended for inclusion on a “watch list” for pathogens. These listings are the result of findings that anthropogenic impacts are impairing beneficial uses of the waters of these basins. This water quality issue is discussed more fully in section VII.10, Hydrology and Water Quality.

State Porter-Cologne Water Quality Act. The Porter-Cologne Act mandates the development of a Water Quality Control Plan for the North Coast Region (i.e., a “basin plan”). The North Coast Basin Plan contains the following prohibitions pertaining to logging, construction, and associated activities (see p. 4-32.00 of the Basin Plan):[4]

1. The discharge of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activities of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited.

2. The placing or disposal of soil, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of

[3] On November 29, 2004, the Regional Water Board adopted Resolution No. R1-2004-0087, which is a policy statement to implement sediment TMDLs throughout the North Coast Region for all sediment impaired water bodies. The goals of the TMDL Implementation Policy are to control sediment waste discharges to impaired water bodies so that the TMDLs are met, sediment water quality objectives are attained, and beneficial uses are no longer adversely affected by sediment. JDSF management will comply with this or any other policy of the North Coast Regional Water Quality Control Board that is put into place during or following the preparation of this DEIR.

[4] The NCRWQCB is proposing to revise the proposed Sediment Waste Discharge Prohibitions and the Action Plan Basin Plan amendment that was released for public review on September 29, 2004. The revised proposal will replace or revise the current “Action Plan for Logging, Construction, and Associated Activities and the Guidelines for Implementation and Enforcement of Discharge Prohibitions Relating to Logging, Construction, or Associated Activities” and will address anthropogenic sediment waste from new projects and existing sediment sources. It is expected that the revised approach will take the form of a Basin Plan Amendment, so there will be another formal public review period, JDSF management will comply with this or any other Basin Plan amendment made by the North Coast Regional Water Quality Control Board that is put into place during or following the preparation of this DEIR.

> whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited.

On June 23, 2004, the North Coast Regional Water Quality Control Board adopted Order No. R1-2004-0030, General Waste Discharge Requirements for Discharges Related to Timber Harvest Activities on Non-Federal Lands in the North Coat Region (GWDR Rule). GWDRs contain discharge prohibitions, receiving water limitations, a requirement for the submittal of some technical reports, an inspection schedule, and a filing/annual fee. The GWDR program has a two-pronged approach to reduce significant sediment input to watercourses: (1) prevention/minimization of new sediment sources, and (2) development and implementation of a program to mitigate existing sediment source areas through an Erosion Control Plan (ECP). Most timber harvest activities on JDSF will be subject to this order. Other activities, primarily those that cause less soil disturbance and have a lower likelihood or causing sedimentation, will be regulated under Order No. R1-2004-0016, Categorical Waiver of Waste Discharge Requirements for Discharges Related to Timber Harvest Activities on Non-Federal Lands in the North Coast Region, adopted June 23, 2004.

The GWDR Rule primarily focuses at the project level [i.e., an Erosion Control Plan (ECP) applies to the entire project (e.g., THP) area including roads used for timber harvest activities and owned by or under the control of the "discharger."] The ECP must contain: (1) an inventory of all controllable sediment discharge sources within the Project area and (2) a schedule for implementation of prevention and minimization management measures from all controllable sediment discharge sources within the Project area. The erosion control plan must include a map showing the location(s) of the site(s) that could discharge sediment, and site-specific designs and/or management measures to prevent and minimize the discharge of sediment. The ECP must be designed to prevent and minimize the discharge or threatened discharge of sediment or other earthen material from controllable sediment discharge sources into waters of the state to the degree necessary to avoid a violation of applicable water quality requirements. The implementation of prevention and minimization management measures must be completed during the period of coverage under General WDRs.

Controllable sediment discharge sources are defined as sites or locations, both existing and those created by proposed timber harvest activities, within the Project area that meet all the following conditions: (1) is discharging or has the potential to discharge sediment to waters of the state in violation of applicable water quality requirements or other provisions of these General WDRs, (2) was caused or affected by human activity, and (3) may feasibly and reasonably respond to prevention and minimization management measures. An inspection plan must be developed to document implementation and effectiveness of management measures used to protect waters of the state. The inspection plan must ensure that all required management measures are installed and functioning prior to rain events, that the management measures were effective in controlling sediment discharge sources throughout the winter period, and that no new controllable sediment discharge sources developed.

These recent orders from the North Coast Regional Water Quality Control Board (NCRWQCB) will help to ensure that violations of waste discharge requirements do not occur from implementation of the DFMP related to timber harvesting. Also, the Water Board has been discussing the potential development of a watershed-wide discharge requirements vehicle that would allow multiple landowners to address sediment discharge issues cooperatively on a watershed basis.

Forest Practice Rules. The Forest Practice Rules provide the baseline framework for management within JDSF. The Hillslope Management approach and Road Management Plan described below will supplement the guidelines already contained within the Forest Practice Rules regarding soil erosion and mass wasting impacts. Pertinent regulations within the Forest Practice Rules are extensive and are described in Appendix 8.

7.4 Proposed JDSF Management Plan Goals and Measures Related to Geology and Soils

The Forest Management Plan has been developed to minimize the potential for management related sediment production and to provide opportunities to reduce existing levels of sedimentation. The DFMP goal and objectives relevant to geology and soils are:

Goal #3 - WATERSHED AND ECOLOGICAL PROCESSES: Promote and maintain the health, sustainability, ecological processes, and biological diversity of the forest and watersheds during the conduct of all land management activities.

Objectives:

- Utilize forestry practices that will maintain stability of hillslope areas and control sediment production from accelerated mass wasting and surface erosion.
- Implement a comprehensive road management plan to reduce sediment production, including upgrading roads remaining in the permanent transportation network and properly abandoning high-risk riparian roads where possible.

The Forest Management Plan augments the applicable standards contained within the Forest Practice Rules, as discussed in this section. The principal elements of the proposed management plan intended to address geological impacts (mass wasting, erosion, etc.) are discussed in DFMP Chapter 3 and DFMP Appendices III and VI. These are:

- **Special Concern Areas.** Special Concern Areas are identified to designate geographically distinct areas with particular characteristics that require special management considerations. Both inner gorge slopes and “shallow landslide potential areas” are designated as Special Concern Areas in the Draft Forest Management Plan. The “shallow landslide potential areas” identified in the DFMP were identified using a distributive computer model (SHALSTAB) based on digital elevation data. Following subsequent review by the California Geological Survey (CGS), however, it was determined that use of the computer model was limited by the accuracy of available digital elevation data and other considerations. Therefore, CGS proposes to utilize recently compiled landslide maps (Short and Spittler 2002a, 2002b; Manson, Sowma-Bawcom, and Parker 2001) and recent field mapping by CGS geologists as the templates to define "Special Concern Areas" in the Final Forest Management Plan.

- **Hillslope Management to Provide for Slope Stability.** As stated in the DFMP, "forest management activities with the potential to destabilize slopes and/or damage aquatic habitat will be mitigated to help maintain stability of hillslope areas and control sedimentation. Special attention will be given to areas where mass wasting tends to occur. Site-specific measures will be developed and applied in THP design and implementation for potential high hazard areas. The goal is to limit management related input of sediment into stream channels that could affect aquatic habitat and water quality."

  The JDSF Management Plan outlines the following currently used methodology for the assessment of slope stability to be conducted during preparation of THPs and other management related activities:

  1. **Office Review of Existing Information.** This information includes: (a) CGS maps of landslide related features and relative landslide potential, (see discussion above about limitations of computer modeling proposed in the DFMP); (b) aerial photographs; and (c) prior THPs and their geologic reports.
  2. **Field Review.** Once office review has been completed, an on-site evaluation will be conducted throughout the project area by an RPF. Areas highlighted during the office review of existing information will receive special attention. The RPF will follow the 1999 "California Licensed Foresters Association Guide to Determining the Need for Input From a Licensed Geologist During the THP Preparation."
  3. **Certified Engineering Geologist Input.** To ensure that harvest units and road designs are proposed that adequately protect unstable areas and inner gorges, a Certified Engineering Geologist (CEG) is to be consulted as appropriate during the design phase of timber sale preparation work to address slope instability and erosion issues identified during office and field reviews. This procedure has been in effect for about 25 years. The 1999 California Licensed Foresters Association (CLFA) Guide to determining the need for input from a licensed geologist during THP preparation *in*: Identification and Management of Unstable areas on Forested Landscapes Workshop Oct. 29, 1999, Hilton Hotel, Sacramento, California, Mendocino County Fieldtrip December 14, 1999, will be used to aid in determining when to call for the services of a CEG. Since January 2000 a CEG has been part of the JDSF staff. Duties of the staff CEG include evaluating the entire project (such as a timber sale) in the field to identify and mitigate potential effects on slope stability. The staff CEG takes part in the preparation stage of the project.

The 1999 CLFA guide described above as an integral part of the review process is a short checklist that states: “If proposed timber operations have a reasonable potential to affect slope stability, and there is a potential for materials from landslides or unstable areas to affect public safety, water quality, fish habitat, or other environmental resources, then a California licensed geologist with experience/expertise in slope stability should be consulted to assess slope stability and assist with designing mitigation measures.” The guidelines include a list of “features associated with unstable areas” intended to provide an RPF with the criteria to identify unstable areas during THP layout. As such, the determination of whether a licensed geologist reviews a plan is within the purview of the RPF preparing the plan.

- **Road Management Plan.** The proposed Road Management Plan is a principal element of the DFMP’s efforts to reduce management-related sedimentation. The goal of the Road Management Plan is to “enhance stream channel conditions…by reducing both fine and coarse sediment loading,” and to “improve water quality by reducing suspended sediment concentrations and turbidity.” The intent of the Road Management Plan is “to provide a systematic program to ensure that the design, construction, use, maintenance, surfacing and abandonment of the Forest’s roads, landings, and road crossings will be conducted to avoid, minimize, or mitigate adverse impacts to aquatic habitats that support anadromous fish, amphibians, and other aquatic organisms,” (DFMP, p. 176-177).[5] To accomplish this, the Road Management Plan includes provisions for abandonment (i.e., “decommissioning”) of older, legacy roads and guidelines for the location and construction of new roads.

  The Road Management Plan includes six major components:

  1. **Inventory.** All JDSF roads will be inventoried during the first 5 years of the plan. The inventory will allow the identification of problem areas, and prioritization of mitigation tasks.
  2. **Design and Construction.** Provides state-of-the-practice design criteria for new roads, landings, and crossings. The intent is to move as many roads as feasible to mid- or upper slope positions. “The goal for the final transportation network is to establish roads in low risk locations that will accommodate appropriate yarding and silvicultural systems, and serve other programs such as recreation and protection.” New roads will generally avoid unstable areas, unless a CEG determines a low potential for sediment delivery to watercourses.
  3. **Use Restrictions.** Minimizes the use of JDSF roads during wet weather conditions, when the potential for road damage and/or drainage control structure damage and sediment generation is highest. Specific rainfall criteria are proposed as a basis for the use or closure of Forest roads during the rainy season.
  4. **Inspection and Maintenance**. Recognizing that “proper maintenance is a key to reducing the long-term contribution of road-related sediment,” the DFMP proposes

[5] Page references to the DFMP refer to the electronic version (PDF) posted at the Board’s website: http://www.bof.fire.ca.gov/pdfs/jdsf_mgtplan_master%203b.pdf.

an Inspection and Maintenance program. Every road and crossing will be visited every two years as part of a "formal" inspection program; problem sites will be recorded on inventory sheets. Between formal inspections, JDSF foresters and other staff will observe road and crossing conditions on an informal basis. "Storm patrol inspections" of known problem areas will be required after large winter storm events. Abandoned roads will be inspected on at least two occasions following the completion of the decommissioning process.

5. **Abandonment.** Problem road areas will be mitigated and "properly" abandoned. In the Road Abandonment Plan, "properly abandoned" roads are defined as roads that have been permanently closed in a manner that prevents erosion, maintains hillslope stability, and re-establishes natural drainage patterns. This definition is in addition to provisions in the Forest Practice Rules, which provide for future access to an "abandoned" road (i.e., the road need only be "reasonably impassable" to standard production 4-wheel drive vehicles; drainage improvements such as culverts may be left in place). In recent literature, the term "decommissioning" has been used to describe the permanent, low-maintenance closure approach described in the JDSF Road Abandonment Plan; in this approach, watercourse crossings are removed, natural channel geometries are restored, and perched fills are pulled back). Target roads in JDSF will include: roads in unstable areas; roads in close proximity to watercourses; roads not needed for management purposes; and roads with excessive amounts of perched fill. Many roads, if abandoned or decommissioned, will retain narrow non-motorized trails for hiking and horse trail riding.
6. **Schedule.** Road repair work will be prioritized based on the relative impacts to critical habitat for coho salmon and steelhead. Secondary factors will include existing rates of sediment delivery to sensitive watercourses, and high potential areas (e.g., areas with high density of riparian roads and/or stream crossings).

- **Operational Implications of Watershed Analysis.** Guidelines are included for improved management of roads, riparian zones, watercourses, and hillslopes as follows:

1. **Roads.**
   a. Roads to be part of the permanent road network are to primarily utilize upper slope locations without ditchlines connected to watercourses where possible.
   b. New roads are to be outsloped with dips where possible and appropriate.
   c. Roads within WLPZs are to be abandoned where other existing feasible routes are available. Where there is no feasible alternative, use will be minimized.
   d. Winter storm inspections are to be used in sample and high-risk areas to ensure that road drainage structures are properly functioning.
   e. Work is to continue to restrict public motorized vehicular access to vulnerable sections of the road network during the winter period and to educate the public regarding the importance of wet-weather road closures.

f. Road segments near watercourses that are to remain in the permanent transportation network and that have inadequate road surfacing are to be surfaced with competent rock to reduce surface erosion.

g. Placement of road spoils within the WLPZ will be avoided.

h. Roads, landings, and crossings are to be built according to the standards described in the JDSF Road Management Plan.

i. Road use restrictions, road inspections, and road maintenance are to be conducted according to the standards described in the JDSF Road Management Plan.

2. **Riparian Zones**.

   Bare soil surfaces associated with management disturbances within WLPZs and ELZs that exceed 100 square feet are to be mulched to achieve at least 95% coverage to a minimum depth of four inches where there is potential for soil detachment and transport to the adjacent watercourse.

3. **Watercourses.**

   a. Watercourse crossings are to be inventoried to locate high-risk crossings; identified crossings are to be upgraded or abandoned.

   b. New and replacement watercourse crossings are to be sized for 100-year discharge events and for passage of woody debris and sediment.

4. **Hillslopes.**

   a. Inner gorge areas are to be evaluated in proposed timber sales.

   b. Aerial yarding systems (e.g., skyline cable, helicopter) will generally be utilized on contiguous slopes steeper than 40 percent.

   c. A CEG is to be consulted as appropriate during the design phase of timber sale preparation to ensure that proposed harvest units and roads adequately address unstable areas and inner gorges.

   d. Winter period timber operations (November 15 to April 1) are to be avoided, except for timber falling and erosion control maintenance.

- **Monitoring and Adaptive Management.** A description of the Monitoring and Adaptive Management goals are presented as Chapter 5 of the DFMP. Monitoring is described as “the process used to evaluate progress toward the stated goals in the management plan for JDSF.” Adaptive management describes the “management strategies that will be implemented if analysis of monitoring results indicate that resource conditions begin to deviate from the desired trajectory.” Under the heading “Watershed Resources,” three goals are presented that are aimed at hillslope management and the reduction of sedimentation impacts:

  Goal: Hillslope Conditions. Mitigate road and crossing problem sites (high priority). As described in the Road Management Plan, problem road sites will be inventoried, prioritized, and mitigated. The road network will be monitored on an informal ongoing basis by JDSF staff, and a formal inspection will be conducted every two years as part of the monitoring program.

Goal: Hillslope Monitoring. Minimize erosion impacts resulting from forest management operations (high priority).

1. Completed THPs that have over-wintered for 1 to 4 years will be monitored. The scope of this THP monitoring will include:
   a. inspection of all watercourse crossings, road segments and landings;
   b. mapping the location of rilling/gullying on roads, landings, etc. that are contributing sediment to watercourses;
   c. mapping the location of mass wasting features (including cutbank/fillslope failures) associated with roads, crossings, and landings, or within harvest units;
   d. mapping the location of road drainage structures (including crossings) that are contributing significant amounts of sediment to watercourses;
   e. measurement of WLPZ canopy for Class I watercourses; and
   f. recording information on the causes of erosion features, proposed improvements, and a schedule for mitigation treatments.
2. Documented erosion problems will be analyzed to determine what management practice or site-specific condition was responsible. Adaptive management solutions will be site specific and based on professional judgment of JDSF staff.

Goal: Minimize Landslides. Minimize landslides associated with roads, landings, and harvest units (high priority).

1. Landslides associated with roads/landings, harvest units, and natural slopes will be inventoried using direct field observations and interpretation of aerial photographs.
2. Road-related landslides will be inventoried under the methodology described in the Road Management Plan. In-unit landslides will be inventoried when encountered; on-going research by the California Geological Survey (CGS) involving mapping landslides associated with timber harvesting may be included in the overall inventory process.
3. The landslide inventory will include a compilation of landslide type, frequency, size, slope, relative activity, certainty, sediment delivery potential, and relationship to past and current forest management practices. The information generated in the inventory will be used to update the CGS Landslide Potential map of JDSF lands on a periodic basis. The frequency of landslide occurrence on areas associated with relatively high landslide potential will be evaluated.

This comparison may also apply to computer modeled landslide potential (i.e., SHALSTAB results).

4. The adaptive management goal is to develop best management practices that minimize the risk of triggering landslides.

7.5 Thresholds of Significance

Based on policy and guidance provided by CEQA (PRC Section 21001 and the CEQA Guidelines), an impact of the proposed project would be considered significant if it results in one or more of the following:

- Exposure of people or structures to potential adverse effects, including the risk of loss, injury, or death involving:

    1. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
    2. Strong seismic ground shaking
    3. Seismic-related ground failure, including liquefaction
    4. Landslides

- Result in substantial soil erosion or the loss of topsoil.

- Location on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

- Location on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property.

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

Please note that sediment (from surface erosion, landslides, and other sources) as a water quality issue is addressed in section VII.10, Hydrology and Water Quality.

7.6 Project Impacts

Impact 1: *Surface Fault Rupture*: (Less than Significant)

JDSF lands are not subject to surface rupture from a known active fault. State Earthquake Fault Zoning maps do not show active faults within the boundaries of JDSF. The nearest known active faults are the San Andreas fault, located offshore about 6 miles to the west, and the Maacama fault, which passes through Willits and the Little Lake Valley about 6 miles east of the Forest. Regardless, surface fault rupture is not a significant issue in rural timberland management. A surface rupture through a forested landscape would have the same effect and impact regardless of the management approach. The impact is less than significant for all seven EIR alternatives.

Impact 2: *Strong Ground Shaking*: (Less than Significant)

As discussed above, the site is located in a seismically active region, and is subject to periodic strong ground shaking. However, because the project is a Forest Management Plan that does not involve buildings or other structures that may be susceptible to strong seismic shaking, it does not "expose people or structures to potential substantial adverse effects." The effects of a strong earthquake in the Forest may include toppling or topping of trees, but these are natural consequences regardless of the management philosophy of JDSF. Earthquakes may trigger landslides, but in a forested setting, these will not have an impact on people or structures. The potential environmental impacts of landslides in general are discussed below. The impact is less than significant for all seven EIR alternatives.

Impact 3: *Seismic-Related Ground Failure, Including Liquefaction*: (Less than Significant)

Because the project area is located in a mostly upland, forested setting, it is not susceptible to secondary seismic effects such as liquefaction. Most secondary ground effects resulting from strong seismic shaking occur in young, unconsolidated deposits under saturated conditions. Within JDSF, these materials are confined to recent alluvial deposits in stream valley bottoms. In the rare occurrence that liquefaction, or other secondary seismic ground effects occur in a recent alluvial deposit, it will not "expose people or structures to potential adverse effects." In addition, the susceptibility of these materials to experience secondary seismic effects does not change under the proposed management plan. The impact is less than significant for all seven EIR alternatives.

Impact 4: *Landslides:* (Less than Significant after Mitigation)

Landslides are a naturally occurring feature in the forested, mountainous landscape that makes up JDSF. The potential for landsliding may be increased by land management practices, including road construction and timber harvest, but there is little potential for exposure to people or structures. Within the boundaries of JDSF, the only significant exposure (of people or structures) to landslide hazard would be in campgrounds or conservation camps near harvest areas or roads. The potential for landsliding is highest, however, during the winter rainy season, when recreational use is typically at its lowest level within the Forest. Furthermore, the DFMP defines a 300-foot special management corridor (i.e., “recreation corridor”) around campgrounds. In these corridors, strong consideration will be given to “values associated with recreation.” Although “appropriate management options within this corridor have been partially developed,” they may include single tree selection, hazard tree removal, or no harvesting (DFMP, p. 77).

Outside the boundaries of JDSF, the exposure to landslide hazards is limited to long run-out associated with debris torrents that may originate within JDSF. The project would increase the likelihood of debris torrents only if management activities (i.e., road building or timber harvest) occur in a setting susceptible to generation of debris slides (i.e., drainage headwalls, etc.).

Debris sliding in the California Coast Ranges typically occurs in predictable settings where specific topographic and hydrologic conditions result in a susceptibility to shallow mass wasting. Specifically, shallow debris sliding occurs most frequently in areas where surface topography forces convergent subsurface flow (i.e., in swales, hollows, and drainage headwalls) and on steep, streamside slopes (i.e., inner gorges). These areas have been identified on the recent relative landslide potential maps for JDSF produced by the California Geological Survey (discussed above), and are subject to special management practices within the Forest Management Plan.

The DFMP proposes a Hillslope Management Element to provide for slope stability. Inner gorge areas and potential unstable features will be identified during THP preparation or road layout, and a Certified Engineering Geologist will be consulted for appropriate measures to avoid or minimize potential impacts (this is a continuation of a practice that has been in effect in JDSF for several years). It is noted that the DFMP calls for review of landslide potential maps derived from computer models such as SHALSTAB; that approach has been identified by CGS as being inadequate until an accurate digital topographic model is available on the State Forest. Historical evidence indicates that “modern” forest management practices result in fewer landslides than earlier methods (Spittler and McKittrick 1995; Cafferata and Spittler 1998), and the inclusion of trained geologists providing site-specific geomorphic analysis and mitigation will further reduce the potential for management-related landsliding. Incorporation of these measures within the management plan would reduce the potential for landslide-related impacts to people and structures to a less than significant level.

“Shallow landslide potential areas” are designated as Special Concern Areas in the Draft Forest Management Plan. The “shallow landslide potential areas” are locales identified via a distributive computer model (SHALSTAB) based on digital elevation data. Following subsequent review by the California Geological Survey (CGS), however, it was determined that use the computer model was limited by the accuracy of available digital elevation data and other considerations. Therefore, CGS proposes to utilize recently compiled landslide maps (Short and Spittler 2002a; Manson, Sowma-Bawcom, and Parker 2001; Manson and Bawcom 2004), relative landslide potential maps (Short and Spittler 2002b; Manson, Sowma-Bawcom, and Parker 2001), and recent field mapping by CGS geologists as the templates to define “Special Concern Areas.”

Mitigation 1. Use CGS-compiled landslide maps (Short and Spittler 2002a; Manson, Sowma-Bawcom, and Parker 2001; Manson and Bawcom 2004) and relative landslide potential maps [Short and Spittler 2002b; Manson, Sowma-Bawcom, and Parker 2001] to (a) identify areas of potential instability during THP preparation, road layout, and other construction activities, and (b) designate "shallow landslide potential areas" as Special Concern Areas.

Monitoring 1.
Timing: During the life of the JDSF Management Plan
Scope: Designation of shallow landslide potential Special Concern Areas throughout the Forest; THPs, road layout, and other construction projects.
Implementation: the Department
Monitoring Responsibility: the Department

With this mitigation, the proposed DFMP (alternative C1) will have a less than significant impact.

Alternative A calls for minimal management. Landslides could result from recently past timber harvests, failure of existing roads (particularly older legacy roads), or natural sources beyond the control of management. Appropriate mitigations are practices such as those provided for in the DFMP (e.g., the Road Management Plan) and Mitigation 1. With the adoption of these mitigations, Alternative A would have a less than significant impact.

Alternatives C2 through F contain measures similar to alternative C1 for landslide prevention and repair of legacy roads with high landslide potential. These measures include avoidance or special treatment of unstable and potentially unstable areas; identification of unstable and potentially unstable areas provided by licensed geologist per guidelines in Forest Practice Rules and Hillslope Management guidelines; and implementation of the Road Management Plan. With the addition of the application of Mitigation 1 requiring use of CGS landslide and relative landslide potential maps, these alternatives would have a less than significant impact.

Impact 5: *Soil Erosion or Loss of Topsoil will Result in a Significant Individual or Cumulative Impact*: (Less than Significant)

Timber harvest, road construction and use, and recreational uses in JDSF can result in significant increases in surface erosion. The principal environmental impacts associated with increased surface erosion rates are degradation of water quality and aquatic habitat, when this material is delivered to watercourses, and loss of soil productivity where fertile topsoils are lost. Water quality and aquatic habitat issues are addressed in more detail in section VII.10, Hydrology and Water Quality.

Timber harvesting can increase surface soil erosion rates by reducing canopy interception of rainfall and by loss of groundcover as a result of yarding and skidding (especially when ground-based equipment is involved) and from site preparation burns (Lewis 1998). The surface erosion potential of timber harvest can be managed by altering the quantity and spatial and temporal patterns of cutting (Lewis 1998). Yarding impacts can be minimized by modifications in the type of equipment used, the time of year yarding is conducted, landing location, and yarding direction. The effects of site preparation burns can be minimized by controlling the heat of the fire, which is a function of the timing of the burn (relative to wind, temperature, and humidity) and the abundance of fuels.

Forestland roads (particularly legacy or old roads) contribute a disproportionate amount of management-related surface erosion by diversion of natural runoff paths, exposure of bare mineral soils on the roadbed, and the creation of potentially unstable cut banks, fillslopes, and watercourse crossings. The erosional impacts of forestland roads can be managed through proper layout and construction, surfacing with erosion resistant materials, careful planning and implementation of watercourse crossings, diligent maintenance, and control of the type and timing of traffic. Existing roads that are chronic sediment sources because of poor design or location should be removed or decommissioned.

Trees at the margins of canopy openings may be subject to wind toppling that can expose areas of erodible, bare soil. In JDSF, these openings are likely to occur near developments (campgrounds, conservation camps), along roads and landings, and in harvest areas (especially clearcuts and Group Selection blocks).

Increased erosion associated with recreational uses of the Forest is primarily a result of grading within campgrounds, which can modify surface runoff patterns, and the use of recreational trails. Mitigation of recreation-related impacts is accomplished by careful planning, construction, and maintenance of improvements and trails, as well as forest patrols to minimize illegal or inappropriate recreational activities.

The proposed Forest Management Plan prescribes harvesting, and road-building methods that minimize the amount and impacts of soil erosion associated with JDSF operations. The management guidelines of the DFMP are intended to supplement the Forest Practice Rules, which contain extensive mitigation of soil erosion. Elements of the DFMP intended to address erosion-related issues are:

- **Road Management Plan:** Describes a strategy to minimize road-related erosion by improving road layout, construction techniques, maintenance, and monitoring. Specific items in the plan call for disconnecting inboard ditches from the hydrologic system, reduction of winter road use, proper abandonment of roads near watercourses, decommissioning selected existing roads, and annual inspection of roads to identify problem areas. These measures will result in a reduction of road related sediment entering streams.

- **Hillslope Management to Provide for Slope Stability:** Describes an approach to minimize the potential for management-related landsliding.

- **Operational Implications of Watershed Analysis:** Includes specific management guidelines intended to protect watershed resources, including several procedures intended to mitigate erosion potential. Guidelines are presented for treatment of Roads, Watercourses, Riparian Zones, and Hillslopes.

- **Other Management Measures:** Language within the plan related to Riparian Management, Silviculture, and Yarding that define management practices to minimize ground disturbance. These include reduced tractor logging on steeper slopes and use of wider equipment exclusion zones to keep ground-disturbing activities further away from stream channels.

The above elements of the DFMP will result in a long-term decrease in average anthropogenic soil erosion rates. However, there may be short-term impacts associated with the implementation of the Road Management Plan. For example, the soil disturbance caused by replacing a poorly placed or undersized culvert may result in a short-term increase in downstream sedimentation, which can be viewed as the cost of preventing a crossing failure that could cause a much larger downstream impact. There also will be a time lag between completing the road inventory, implementing the restoration activities, and realizing the decrease in erosion rates from road-related sources.

Other major timberland owners on the Big and Noyo River watersheds are undertaking their own programs to reduce anthropogenic soil erosion. These include MRC, Hawthorne Timber Company, and the Department of Parks and Recreation (on their recently acquired Big River Unit). These positive steps on other ownerships in the JDSF EIR assessment area are resulting from changes in landowner management direction, evolving Forest Practice Rules, and increasingly strict water quality regulations applied by the North Coast Regional Water Quality Control Board. Through these steps, progress is being made in reducing anthropogenic sediment sources in the Noyo and Big River watersheds. Over time, steps already taken by landowners and the land management activities and management measures proposed in the DFMP will result in a decrease in sediment contributions from legacy sources (such as older roads) and will strictly minimize sediment contributions from future management activities.

As a result of the above factors, soil erosion and loss of topsoil related to the proposed project (alternative C1) will result in less than significant individual and cumulative effects.

Under alternative A, the minimal levels of management will result in no new anthropogenic soil erosion or soil loss sites. However, absence of a proactive road management plan or systematic evaluation of problematic road sites will forego the significant reductions soil erosion that can be achieved with management strategies presented in the DFMP. These potential impacts could be mitigated by implementing the sediment reduction and control measures incorporated into the DFMP.

Alternative B would include new soil disturbing management activities without the benefit of many of the protective measures included in the proposed project. The

Forest Practice Rules and THP review process would be the primary mechanisms for preventing soil erosion and sediment production from timber management activities. In addition, legacy sediment sources will **not** be systematically addressed absent proactive road management or systematic evaluation of problematic road sites. With the incorporation of measures similar to those included in the DFMP as mitigations, alternative B would result in less than significant impacts.

Alternatives C2 through F contain essentially the same soil erosion and soil loss protection measures as the project alternative, C1. Alternatives D-F would result in less or no even-aged management, which can result in more soil disturbance than uneven-aged management as a result of more frequent entries. Alternative F calls for an accelerated implementation of the Road Management Plan, which would result in a more rapid reduction of legacy sediment sources, but would also increase the magnitude of short-term impacts resulting from restoration activities. Alternatives C2 through F would result in a less than significant impact.

Impact 6: *Location on Unstable Geologic Unit or Soil:* (Less than Significant after Mitigation)

The California Coast Range is a geomorphically dynamic environment with naturally high rates of landsliding. Land management in this sensitive environment may lead to an increased potential for landsliding if not carefully planned and implemented. The limited potential for lateral spreading, liquefaction, or subsidence during an earthquake is restricted to young alluvial deposits in stream channels, and is not influenced by the proposed project.

Landsliding potential may be increased by the proposed project primarily as a result of the effects of timber harvest (i.e., modification of the hydrologic budget of a slope and root strength issues) and the location or type of roads. Many landslides in the California Coast Ranges, however, occur in predictable topographic and geologic settings, or occur repeatedly in the same location. As such, the potential increase in landslide susceptibility can be controlled by identification of unstable or potentially unstable areas and the use of special operational procedures to avoid or minimize potential impacts to those areas.

The DFMP proposes to mitigate the potential for management-related landsliding through the identification of unstable areas, and either avoidance or the implementation of low-impact management practices in these areas. Inner gorges and shallow landslide potential areas are to be identified as Special Concern Areas where guidelines contained primarily within the Road Management Plan, the Hillslope Management discussion, and the day-to-day guidelines presented in the Operational Implications of Watershed Analysis include provisions for the inventorying and treatment of unstable features associated with roads and hillslopes.

Problem areas will be mitigated or avoided, as appropriate, and a Certified Engineering Geologist will review inner gorge slopes during layout of timber sales and will review operations or improvements proposed on or near unstable areas.

Per discussion above under “Impact 4: Landslides,” CGS identified problems with the DFMP’s reliance on computer models for slope stability (i.e., SHALSTAB) and recommended using CGS maps for landslides and relative landslide potential (Manson and Bawcom 2004; Manson, Sowma-Bawcom, and Parker 2001; Short and Spittler 2002a, 2002b).

Mitigation 2. Use CGS-compiled landslide maps (Manson and Bawcom 2004; Manson, Sowma-Bawcom, and Parker 2001; Short and Spittler 2002a) and relative landslide potential maps (Manson, Sowma-Bawcom, and Parker 2001; Short and Spittler 2002b) to (a) identify areas of potential instability during THP preparation, road layout, and other construction activities, and (b) designate “shallow landslide potential areas” as Special Concern Areas.

Monitoring 2.
Timing: During the life of the JDSF Management Plan
Scope: Designation of shallow landslide potential Special Concern Areas throughout the Forest; THPs, road layout, and other construction projects.
Implementation: the Department
Monitoring Responsibility: the Department

Impact 7: *Location on Expansive Soil:* (No Impact)

Soils with significantly expansive properties have not been identified in JDSF. Furthermore, because the project does not involve substantial development of engineered structures, it is not subject to the effects of expansive soil properties. The finding of no impact applies to all seven of the EIR alternatives.

Impact 8: *Soils Incapable of Supporting Septic Systems:* (No Impact)

Again, because the project does not involve the development of significant numbers of structures, it is not subject to the constraints of site-specific soils conditions. Although some soils within the JDSF may be unsuitable for septic systems, the abundance of space allows for siting of facilities on areas with suitable conditions. The presence of existing campgrounds and conservation camps indicate that facilities can be successfully developed in the project area. The finding of no impact applies to all seven of the EIR alternatives.

7.7 Alternatives Comparison

A comparison of geology and soils related impacts among the various alternatives is presented in Table VII.7.7.

TABLE VII.7.7. Comparison of Geology and Soils Related Impacts in Relation to the Various Alternatives.

Alternatives						Discussion
Impact*	**1**	**2**	**3**	**4**	**5**	***Impact Levels: (1) Beneficial (2) No Impact (3) Less than Significant (4) Less than Significant after Mitigation (5) Significant–Mitigation Not Feasible**
Impacts 1-3. Exposure of people or structures to adverse effects involving surface fault rupture, strong seismic shaking, or other seismic-related ground failure.						
Alt. A						No active faults are mapped or otherwise known to occur within JDSF lands. Furthermore, with the JDSF managed for natural resources, minimal human exposure to fault related hazards would occur. This impact is considered less than significant under all seven Forest management alternatives.
Alt. B						
Alt. C1 May 2002 DFMP						
Alt. C2 Nov. 2002 Plan						
Alt. D						
Alt. E						
Alt. F						
Impact 4. Exposure of people or structures to landslides.						
Alt. A						No timber-harvest-related landslides would occur under this scenario; however, landslides could result from failure of existing roads, particularly older legacy roads, without proper mitigation similar to the management strategies presented in the DFMP, including the Road Management Plan, and Mitigation 1, above.
Alt. B						This alternative includes substantial amounts of timber harvest and it does not address legacy road problems. Its protective measures related to landslides are largely those of the Forest Practice Rules. To avoid exposure of people or structures to landslides, apply mitigations similar to the mangement strategies presented in the DFMP, including the Road Management Plan, Hillslope Management guidelines, and Mitigation 1, above.
Alt. C1 May 2002 DFMP						Landsliding potential is less than significant with mitigation under management scenarios C1 through F, given measures proposed in the DFMP and Mitigation 1. These measures include avoidance or special treatment of unstable and potentially unstable areas. Identification of unstable and potentially unstable areas provided by licensed geologist per guidelines in Forest Practice Rules and Hillslope Management guidelines of the DFMP (Alts. C1, C2, D, E, and F). Apply Mitigation 1, requiring use of CGS landslide and relative landslide potential maps.
Alt. C2 Nov. 2002 Plan						
Alt. D						
Alt. E						
Alt. F						

Table VII.7.7. Comparison of Geology and Soils Related Impacts in Relation to the Various Alternatives.

Alternatives						Discussion
Impact*	**1**	**2**	**3**	**4**	**5**	***Impact Levels: (1) Beneficial (2) No Impact (3) Less than Significant (4) Less than Significant after Mitigation (5) Significant–Mitigation Not Feasible**
Impact 5: Soil erosion or loss of topsoil will result in a significant individual or cumulative impact.						
Alt. A				■		Absence of a proactive road management or systematic evaluation of problematic road sites will result in significant soil erosion without proper mitigation similar to the management strategies presented in the DFMP. Harvesting activities under alternative B pose a risk of erosion impacts unless mitigated using measures included in the DFMP for Hillslope Management guidelines, CEG evaluations, etc.
Alt. B				■		
Alt. C1 May 2002 DFMP			■			The Road Management Plan provides for an inventory and control of potentially significant road-related erosion sites, which will provide a beneficial long-term result. Amounts of harvest-related surface erosion are relative to the amount of area harvested, especially areas subject to even-aged management. Under alternatives C1 through F, there is a short-term unavoidable impact associated with the implementation of the road management plan. Under alternative F, there is an accelerated implementation of the Road Management Plan that will result in more rapid reduction in road-related sediment sources.
Alt. C2 Nov. 2002 Plan			■			
Alt. D			■			
Alt. E			■			
Alt. F			■			
Impact 6. Location on unstable geologic unit or soil.						
Alt. A				■		No timber-harvest-related landslides would occur under this scenario; however, landslides could result from failure of existing roads, particularly older legacy roads, without proper mitigation.
Alt. B				■		Geologic review of timber harvest areas and roads as per Forest Practice Rules provides minimal protection; Hillslope Management guidelines, additional measures similar to the management strategies presented in the DFMP, and application of Mitigation 2 would mitigate potential impacts to a less than significant level.
Alt. C1 May 2002 DFMP				■		Geologic review of timber harvest areas and roads as per Forest Practice Rules and Hillslope Management guidelines of DFMP, and through Mitigation 2 to use CGS maps of landslides and relative landslide potential to identify potentially unstable areas, will preclude operations on unstable features and soils. Alts. D, E, and F further preclude operations within inner gorges.
Alt. C2 Nov. 2002 Plan				■		
Alt. D				■		
Alt. E				■		
Alt. F				■		
Impact 7. Location on expansive soil.						
Alt. A		■				No such problematic soils have been identified.
Alt. B		■				
Alt. C1 May 2002 DFMP		■				

Table VII.7.7. Comparison of Geology and Soils Related Impacts in Relation to the Various Alternatives.

Alternatives						Discussion
Impact*	**1**	**2**	**3**	**4**	**5**	***Impact Levels: (1) Beneficial (2) No Impact (3) Less than Significant (4) Less than Significant after Mitigation (5) Significant–Mitigation Not Feasible**
Alt. C2 Nov. 2002 Plan						
Alt. D						
Alt. E						
Alt. F						
Impact 8. Soils incapable of supporting on-site septic systems.						
Alt. A						Future developments requiring on-site septic systems are minimal under any alternative, though alternative E, with its emphasis on recreation, would require more development of recreational facilities with a potential need for septic systems than the other alternatives. In any case, suitable soils for on-site sewage disposal are common in JDSF.
Alt. B						
Alt. C1 May 2002 DFMP						
Alt. C2 Nov. 2002 Plan						
Alt. D						
Alt. E						
Alt. F						